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UNITED STATES DISTRICT COURT

NORTHERN DISTRICT OF CALIFORNIA

NATTO IYELA GBARABE, et al,

Plaintiffs,

vs.

CHEVRON CORPORATION,

Defendant.

CASE NO.: 14-cv-00173-SI

SUPPLEMENTAL EXHIBIT IN SUPPORT OF PLAINTIFF'S MOTION FOR AN ORDER ADMITTING INTO EVIDENCE THE VERDE/PHYSALIA FAR FIELD SEDIMENT SAMPLE ANALYSES FOR CONSIDERATION AS PART OF CLASS CERTIFICATION HEARING.

DATE: DECEMBER 9, 2016
TIME: 9.00 a.m.
COURTROOM: ONE

COMES NOW plaintiff NATTO IYELA GBARABE, through his attorneys of record, and submits the following exhibit in support of plaintiff's motion for an order that the Far Field Sample Analyses, received from plaintiff's environmental experts, Verde, on October 26, 2016 and served on defendant that same day, be deemed admissible as evidence supportive of plaintiff's Motion for Class Certification and considered by this Court for such purposes in hearing and ruling upon said motion. This exhibit was erroneously omitted upon the filing of the motion and supporting documents on November 16, 2016 (*ECF* # 206).

The attached exhibit is as follows:

EXHIBIT C - The KS Endeavor Blowout Incident: Residual Marine Benthic Impact Assessment - Final Report; Near & Far Field Survey Areas, by Physalia Applied Sciences in conjunction with Verde Environmental Consultants Ltd, Authors Dr. Marcus W. Trett and Dr. Simon J. Forster, dated October 26, 2016.

Dated: November 24, 2016

PERRY AND FRASER

/s/

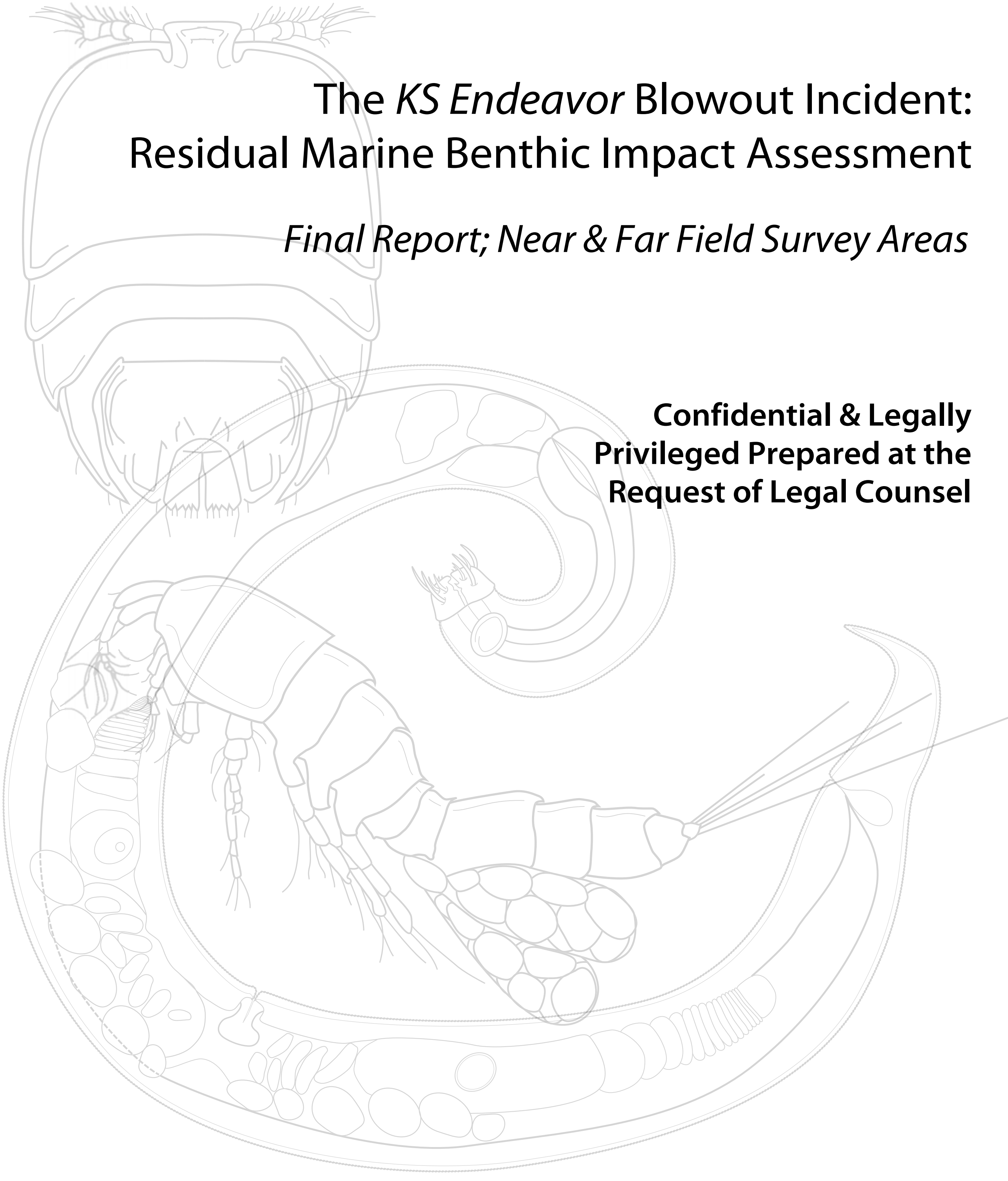
Neil J. Fraser, Attorney for Plaintiff

EXHIBIT C

The *KS Endeavor* Blowout Incident: Residual Marine Benthic Impact Assessment

Final Report; Near & Far Field Survey Areas

Confidential & Legally Privileged Prepared at the Request of Legal Counsel



Independent ecological/environmental and mathematical analyses undertaken for monitoring and compliance purposes on behalf of

Verde Environmental Consultants Ltd

Physalia
Applied Sciences

www.physalia.com

The *KS Endeavor* Blowout Incident Residual Marine Benthic Impact Assessment;

Final Report; Near & Far Field Survey Areas

Physalia Report Version 1.1
26th October 2016

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Applied Sciences

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VERSION RECORD

Version no.	Implemented by	Revision Date	Approved By	Approved Date	Comments
1.0	Dr. S.J. Forster	21/10/2016	Dr. M.W.Trett	21/10/2016	Draft
1.1	Dr. S.J. Forster	26/10/2016	Dr. M.W.Trett	26/10/2016	Final

Signed:

Date: 26/10/2016

Signed:

Date: 26/10/2016

Contributors to the Present Scientific & Technical Report

Dr. Marcus W. Trett - Scientific Director, Physalia Limited

Dr. Simon J. Forster - Senior Ecologist, Physalia Limited

Table of Contents

Appendices

Non-Technical Summary

The Marine Coastal Survey Grid and Sampling Stations

- The *KS Endeavor* residual marine benthic impact assessment comprised collection of materials for analyses from 74 seabed sites within a sampling grid that extended approximately up to 12 km on either side of the former *KS Endeavor* well head site.

- The survey area was partitioned into an inner (near-field) survey grid comprising 48 sampling stations and an outer, far-field grid comprising a further 26 sampling stations. The near-field survey grid was designed to provide details of the biological and physico-chemical conditions at, and in the vicinity of, the rig blow-out location and was restricted to an area extending approximately 2.7 km from the former *KS Endeavor* platform site. The far-field seabed sampling stations were examined to provide data on any extended/more widely spread effects of the blowout incident and to provide details of the background conditions against which any residual impacts and their effects could be compared and assessed.

- Owing to time constraints imposed on the investigation by the deadline for the initial submissions of evidence, an interim report presenting the findings of the 46 near-field samples was submitted by Physalia in April 2016. The remaining 26 far-field samples were analysed subsequently and the combined findings of the full data set are presented and reported in the present document (Physalia, October 2016).

Marine Sampling Programme – Design and Implementation

- At each of the sampling stations, sediment samples were collected from the seabed for subsequent biological/community analyses based on quantitative, site-by-site data.

- Sediment physico-chemistry samples were also collected for the analyses of a suite of heavy metals, organic compounds, total organic carbon and particle size distribution (granulometric) analyses.

- Conspatial samples from the sampling sites were also collected for the assessment of the macroinvertebrates (animals greater than 0.5 mm in size) and the meiofaunal invertebrates (animals within the approximate size range 0.05 mm to 1 mm).

- Of the meiofaunal bioindicator species present, the two most abundant and diverse groups were analysed quantitatively. These comprised the nematodes (free-living roundworms) and the harpacticoid copepods (small 'shrimp-like' crustaceans).

Sediment Type

- Throughout most of the near and far field survey areas the benthic substrata comprised predominantly fine sediments. Of the 74 sites sampled, 64 were classified as 'muds' or 'sandy mud' with three being categorized as 'muddy sands'.

- The substrates at seven sites were characterised by sands with little or no silt fractions present. These were located either on the perimeter of, or in the immediate vicinity of, the *KS Endeavor* blowout crater.

- At six sites, all within 1.3 km of the former well head, exposed, thin layers of sand were observed overlying silt-dominated sediments.

Sediment Chemistry

- A comprehensive range of chemical analyses was undertaken on sediment samples collected in the January/February marine survey. These were analysed by the staff at Jones Environmental Laboratory Ltd in the UK.

- The distribution of metals throughout the near and far field survey grid was found to correspond closely with the distributions of fine silts/muds (< 63 µm sediment fractions). It is considered most likely that this is due to the propensity of the clay-associated alumina-silicates to adsorb/bind positively charged metal ions. Exceptions to this distribution pattern were (i) chromium which exhibited peak concentrations at a sandy site adjacent to the former *KS Endeavor* site and (ii) calcium and strontium that both exhibited elevated concentrations at sites to the south and south west extent of the survey area.

- Site 62, located approximately 625 metres to the north east of the former *KS Endeavor* site, did not conform to the fine silts/mud distribution pattern. Despite the relatively low proportions of silt/mud and low aluminium content identified in the sediment analyses present at this sampling station, the highest concentrations of 12 metals were documented at this location. The reasons for this are uncertain.

- Normalisation of the sediment metals to aluminium indicated the presence of above background concentrations of a range of metals at, and in the vicinity of, the *KS Endeavor* blowout crater. These are documented and described.

- Total organic carbon (TOC) conformed largely to the distribution of the < 63 µm, silt/clay fractions and the aluminium concentrations. An exception to this was the anomalous substrata present at Site 62 that yielded the highest TOC content (5.49% TOC as compared to a survey area mean value of 0.95 %).

- Dioxins and furans were detected throughout the near-field survey area. The distribution of a number of these persistent organic pollutants conformed to those of the < 63 silt/clay sediment fraction and, by proxy, the aluminium concentrations.

However, the distribution of other dioxins and furans congeners indicated the *KS Endeavor* blowout site as the potential source of these compounds.

- Heavy aromatic and aliphatic hydrocarbons (C16 - C21 and C21 - C35 ranges) were detected within the survey area. The concentrations were elevated at silt/mud dominated sites adjacent to the *KS Endeavor* blowout crater and absent from the majority of the sites in the south east half of the far field survey area.

- At no site were poly-aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs) or semi-volatile organic compounds (SVOCs) recorded at concentrations above laboratory reporting limits.

Benthic Macrofauna

- A total of 97 taxa ("species") of macrofaunal invertebrates was identified in the survey samples, the most abundant and widespread group being the polychaete annelids (worms), contributing 34 taxa to the survey area total.

- The benthic macrofauna communities were characterised by low densities and low species richness values for the invertebrate assemblages. Eleven of the 74 near and far field sampling stations failed to yield macrofauna in the samples analysed. Within, or in the immediate vicinity of, the blowout crater six samples yielded no macrofauna whilst a further four sampling sites supported single species only.

- The mean species richness values and densities of the macrofauna species in the near field survey area (i.e. in close proximity of the blowout site) were lower than those of the far field area. The differences observed were statistically significant ($p < 0.001$). This indicates strongly that the macrofauna assemblages of the nearfield survey area had not recovered to background (pre-incident) conditions 4 years after the incident.

Benthic Meiofauna

- The meiofaunal nematodes that include some of the most robust, stress-tolerant species on the planet proved to be the most abundant and diverse group of invertebrate animals recorded in the *KS Endeavor* near and far field survey area. A total of 160 distinctive species/taxa was identified at densities of up to 14,848 nematodes litre^{-1}.

- The lowest densities and diversities of nematodes were recorded at the sites located in the *KS Endeavor* blowout crater. Here densities of just 9, 16 and 36 nematodes litre^{-1} were identified and comprised 1, 2 and 3 species, respectively. These are noted to be exceptionally low values for marine benthic nematode communities and indicate the operation of environmental stresses including sediment instability.

- Distinctive nematode community structures were documented in association with sandy sites at and adjacent to the perimeter of the *Endeavor* blowout crater. These communities included several species that were unique within the survey area.

- Of the 73 meiofaunal nematode communities analysed, 46 were identified as structurally-related, co-occurring species and were grouped in 4 clusters (Clusters A to D).

- The multivariate correlation analyses that assess the associations between the structures of the nematode communities (i.e. species present and their relative abundances) and the measured physico-chemical parameters (sediment particle size characteristics and sediment chemistry), highlighted a suite of metals and particle size fractions that proved to be the most significant correlates with the community structures. Three persistent organic pollutants (dioxins) and total organic carbon (TOC) were also statistically significantly correlated with the variation in the nematode community structures.

- The meiofaunal harpacticoid copepod (microscopic ‘shrimps’) were poorly represented throughout the *KS Endeavor* survey area. The analyses identified 34 out of 73 sites at which no copepods were recorded at all. Single species only were observed at a further 21 sites.

- Respectable copepod species richness and densities values occur at sandy sites only adjacent to the *KS Endeavor* site. This was due to the colonisation of the sand habitat by two “sand specialist species” that occurred exclusively at these locations.

Evidence of Residual Impacts

- The side scan sonar bathymetric assessment undertaken during the 2016 field survey demonstrated the presence of a crater of equivalent proportions to that detailed by Chevron three years beforehand, indicating that little or no infilling had occurred during the intervening period.

- The side scan sonar bathymetric assessment demonstrated that a minimum of 4,500,000 m^3 of material had been displaced from the former *KS Endeavor* site during the blowout incident. It is implausible that the deposition of such quantities of material onto the surrounding seabed did not result in an expansive impact on the benthic faunal communities.

- In the vicinity of the *KS Endeavor* site the sediment type was modified from the ‘background’, silt-dominated substrata and comprised well sorted sands that had emanated from the blowout crater. These modified habitats are associated with persistent and on-going impacts on the seabed (benthic) ecology.

- At six locations in the vicinity of the former well head site, thin layers of sand were observed overlying fine, silt-dominated sediments. Had these been deposited during the initial blowout and fire incident in 2012, the sands would have been covered by the alluvial silts that emanate from the delta and incorporated with the silt substrata. This had not occurred indicating that these sands had been deposited within this area in the relatively recent past. Given that the only rational source of sands in this area would have been the *KS Endeavor* blowout crater, these observations indicate that sporadic displacement of sands from the crater had continued at least up until the January 2016 survey. Such displacement of sand from the crater would only occur if significant volumes of gas were emitted up through the sandy substrata beneath the former well head site.

- The results of the sediment metal analyses demonstrate correlations of metal concentrations with the distribution of the fine silt/clay sediment. However, following normalisation with aluminium, it was shown that above background concentrations existed at and in the vicinity of the blowout crater and this indicated a residual 'chemical footprint' associated with the blowout incident that is still discernable four years after the blowout incident.

- The furans OCDF and 1,2,3,6,7,8-HxCDF, persistent organic pollutants (POPs), were recorded at disproportionately high concentrations at the sandy, low silt sites in, and in the vicinity of, the *KS Endeavor* blowout crater, implicating the blowout site as a source of these compounds.

- The dioxin 1,2,3,4,7,8-HxCDD and the furans 2,3,4,7,8-PCDF and 2,3,7,8-TCDF were detected in the near field sediment and to the east of the *KS Endeavor* site, in the prevailing direction of the water currents and in the direction of dispersion of crater materials, providing further supporting evidence of the blowout site being the source of persistent organic pollutants (POPs).

- Normalisation of the dioxin and furan data to aluminium (a proxy for fine, silt/clay sediments) indicated that above background concentrations of a range of dioxins and furans occurred in the vicinity of the *KS Endeavor* crater, implying again that the blowout incident was a source of the organic compounds.

- In addition to the mobilisation and re-distribution of sands, it is inevitable that fine silt/clay fractions were disturbed and re-distributed during the blowout incident. Both the metals and the persistent organic pollutants identified in the 2016 survey have a propensity to adsorb to the silt/clay fraction. Therefore, contaminants created or liberated during the *KS Endeavor* conflagration would also have been broadcast over an extensive area of the Bayelsa coastal marine habitat. Evidence provided by the far field chemistry results supports this suggestion.

- In terms of the macrofauna, sites in, and in the immediate vicinity of, the blowout crater displayed particular depauperate assemblages of the larger invertebrate species with six sites yielding no macrofauna in the seabed samples and an additional four sites at which single specimens were observed.

- The mean densities and mean species richness values of the nearfield macrofaunal assemblages were statistically significantly lower than those from the far field survey area. This indicated that the macrofaunal communities of the nearfield sites have as yet not recovered fully from the impacts of the *KS Endeavor* blowout incident.

- The meiofaunal nematode communities provided high quality evidence of persistent, on-going, adverse environmental conditions in the immediate vicinity of the former well head site (within the blowout crater) with assemblages comprising between one, two and three species only and occurring at very low total densities relative to those at further afield locations. Depauperate meiofaunal assemblages of this type would exist only under conditions of physical and/or chemical stress.

- Characteristic meiofaunal nematode assemblages were documented at sites where crater-derived sands dominated the sea-bed substrate in the close proximity to the *KS Endeavor* site. The species composition of these assemblages deviated markedly from those of the background muddy sediments indicating atypical seabed conditions. This demonstrates an on-going ecological impact associated with the blowout incident.

- Evidence indicative of on-going crater disturbance is presented and can be summarised as follows:

    - Comparison of the bathymetric surveys undertaken in 2013 and 2016 indicates little or no infilling of the crater had occurred during the intervening period. This implies that the crater is being maintained by the on-going expulsion of sedimentary materials that would otherwise fill the crater.

    - At sites in the vicinity of the blowout crater, thin layers of sand were observed overlying fine, silt-dominated sediments. That these had not been covered in fine silt/muds and had not been incorporated into the muddy sediments is consistent with their recent deposition. The crater is the only rational source of the sand and, therefore, recent deposits of sand can only have emanated from the blowout site.

    - The side scan results demonstrated backscatter feature that were consistent with on-going gas seepages (Irish Hydrodata, 2016)

    - The nematode communities within the crater sediment were particularly depauperate in terms of both their species richness and total abundances. Over the four years since the blowout incident it would be expected that these

communities would have recovered to equivalent diversities as those recorded at sites beyond the crater. As this had not occurred, it can be deduced that the crater habitats were subject to persistent or sporadic chemical and/or physical perturbations.

1 INTRODUCTION

This document forms the second report that describes the findings of the marine benthic survey undertaken by Physalia Limited, for and on behalf of Verde Environmental Limited, in relation to the impacts of the Chevron *KS Endeavor* blow-out incident in coastal waters offshore of Nigeria. The first report was submitted in April 2016 (Physalia, 2016a, dated 07/04/2016). Due to severe time constraints imposed by the initial submission of evidence deadline (April 2016), analyses of the full series of samples that were collected during the marine survey were not feasible within the given time frame. Consequently, sediment materials from 48 only of the 74 sampling sites located in the "near-field" (i.e. sites within and surrounding the blow-out crater) were analysed, described and presented in the previous ("preliminary") report (Physalia 2016a).

The present, full report provides the results of the analyses and associated observations based on the complete suite of sites sampled in the 2016 survey area (i.e. the combined analytical results of investigations relating to all 74 sampling stations). Note that the incorporation of data from laboratory analyses of far-field materials has necessitated a re-run of the mathematical/multivariate analyses in order to provide a valid assessment of the patterns in the relationships between the bioindicator communities and, separately, the physico-chemistries of the sediments. The resulting, combined near- and far-field assessment described in the sections below provides a robust, comprehensive evaluation of the patterns in, and the relationships between, these parameters and their spatial distributions within the survey area.

Details of the *KS Endeavor* blowout incident, the background to the 2016 benthic survey, the rationale of the survey approach and the key staff involved in the study are presented in the Physalia (2016a) report and should be referred to as required.

1.1 OBJECTIVES OF PROJECT

Following due consideration of the available information, the apparent contradictions in the pre-existing reports and the requirements for the assessment of the residual impacts of the *KS Endeavor* blowout, the aims of the 2016 benthic survey can be summarised as:

- The assessment and description of the benthic faunal (meiofauna and macrofauna) communities/assemblages and their spatial distributions in the vicinity of the *KS Endeavor* blowout site (Funiwa Deep-1A exploration well);

- The assessment and description of the physico-chemical conditions in the benthic sediments in the vicinity of the *KS Endeavor* blowout site, including both natural

and anthropogenic, oil- and gas-related parameters and the establishment of the spatial distribution of each of these parameters;

- Evaluation of potential correlations between the structures of the benthic faunal communities (i.e. the species present and their relative abundances at each sampling site) and the physico-chemical conditions of the seabed based on multivariate analytical techniques, and;

- The identification and description of detectable residual effects of the *KS Endeavor* blowout on the benthic habitats and invertebrate communities four years after the initial incident.

1.2 PRELIMINARY REPORT

Initial submission of evidence for consideration by the US courts during the Natto Iyela Gbarabe v Chevron litigation case was due by mid-April 2016. Given that the survey field work was not completed until beginning February 2016, there was insufficient time to undertake the analyses of samples from all 74 sampling site. Accordingly, the samples from the nearfield sites (namely Sites 27 to 74) were analysed initially and were reported in a preliminary report dated 7th April 2016 (Physalia, 2016a). The information presented in Physalia (2016) formed the basis of the evidence presented by Dr Marcus Trett, Dr Simon Forster and Dr Beatriz Urbano during depositions taken by Chevron legal representatives between 3rd and 6th May, 2016.

1.3 THIS REPORT

Following the completion of the analyses and reporting of the nearfield survey area data, it was concluded that the additional, far-field data would be required. This would confirm whether the benthic (seabed) conditions in the immediate vicinity of the *KS Endeavor* site were a function of the environmental impact of the blowout incident or if the findings were consistent with more widespread, 'background' conditions. Accordingly, the remaining 26, far field survey site samples were analysed enabling the combined marine physico-chemical and ecological data to be assessed across the larger seabed area.

The present report describes the findings of the far field samples and their implications for the interpretation of the previously reported nearfield survey area data. Verbal descriptions of the results of the nearfield sample analyses, already presented in the Physalia (2016a) report, have not been repeated here excepting where new information has become available and is pertinent to the far field sampling site data and their interpretation. However, reference should be made to the previous, Physalia (2016a) report for both background information and for details of the materials and methods adopted in the Physalia investigations.

Site	° North	° East	Site	° North	° East
1	4.265337	5.853850	38	4.345337	5.785667
2	4.309170	5.887350	39	4.348170	5.787850
3	4.254654	5.823933	40	4.351120	5.790100
4	4.340987	5.889817	41	4.353987	5.792283
5	4.309287	5.842633	42	4.358237	5.795517
6	4.297354	5.811317	43	4.347449	5.782703
7	4.341004	5.844300	44	4.350420	5.784933
8	4.299537	5.781083	45	4.353370	5.787133
9	4.319520	5.804500	46	4.356237	5.789367
10	4.342470	5.821933	47	4.352485	5.785417
11	4.371154	5.835217	48	4.339887	5.774783
12	4.309287	5.751667	49	4.344020	5.777800
13	4.330504	5.767533	50	4.352248	5.784121
14	4.374354	5.800717	51	4.353806	5.785311
15	4.395970	5.817467	52	4.361504	5.791050
16	4.335054	5.734817	53	4.365987	5.794483
17	4.363354	5.747233	54	4.353629	5.784006
18	4.385270	5.763867	55	4.349654	5.779833
19	4.406620	5.788650	56	4.352554	5.782033
20	4.362754	5.724400	57	4.355504	5.784283
21	4.406670	5.757417	58	4.358420	5.786467
22	4.395654	5.727567	59	4.347270	5.773533
23	4.363704	5.680350	60	4.351787	5.776967
24	4.449654	5.745483	61	4.354770	5.779233
25	4.395670	5.681500	62	4.357654	5.781433
26	4.439070	5.714450	63	4.360554	5.783650
27	4.333587	5.800533	64	4.364787	5.786883
28	4.342337	5.807183	65	4.346470	5.766267
29	4.334320	5.790783	66	4.355054	5.772700
30	4.343154	5.797517	67	4.359404	5.776017
31	4.351770	5.804067	68	4.363770	5.779333
32	4.333337	5.783700	69	4.372420	5.785950
33	4.342020	5.789983	70	4.353704	5.764983
34	4.346337	5.793267	71	4.362437	5.771900
35	4.350687	5.796583	72	4.371237	5.778367
36	4.359487	5.803017	73	4.363220	5.761650
37	4.340770	5.782183	74	4.372320	5.768500

Table 2.1. The latitude and longitude of the near-field (Sites 27 to 74) and the far-field (Sites 1 to 26) survey grids designed for the *KS Endeavour* residual marine benthic impact assessment, January/February 2016. The former well head was located at N 4.353070° E 5.784733°.

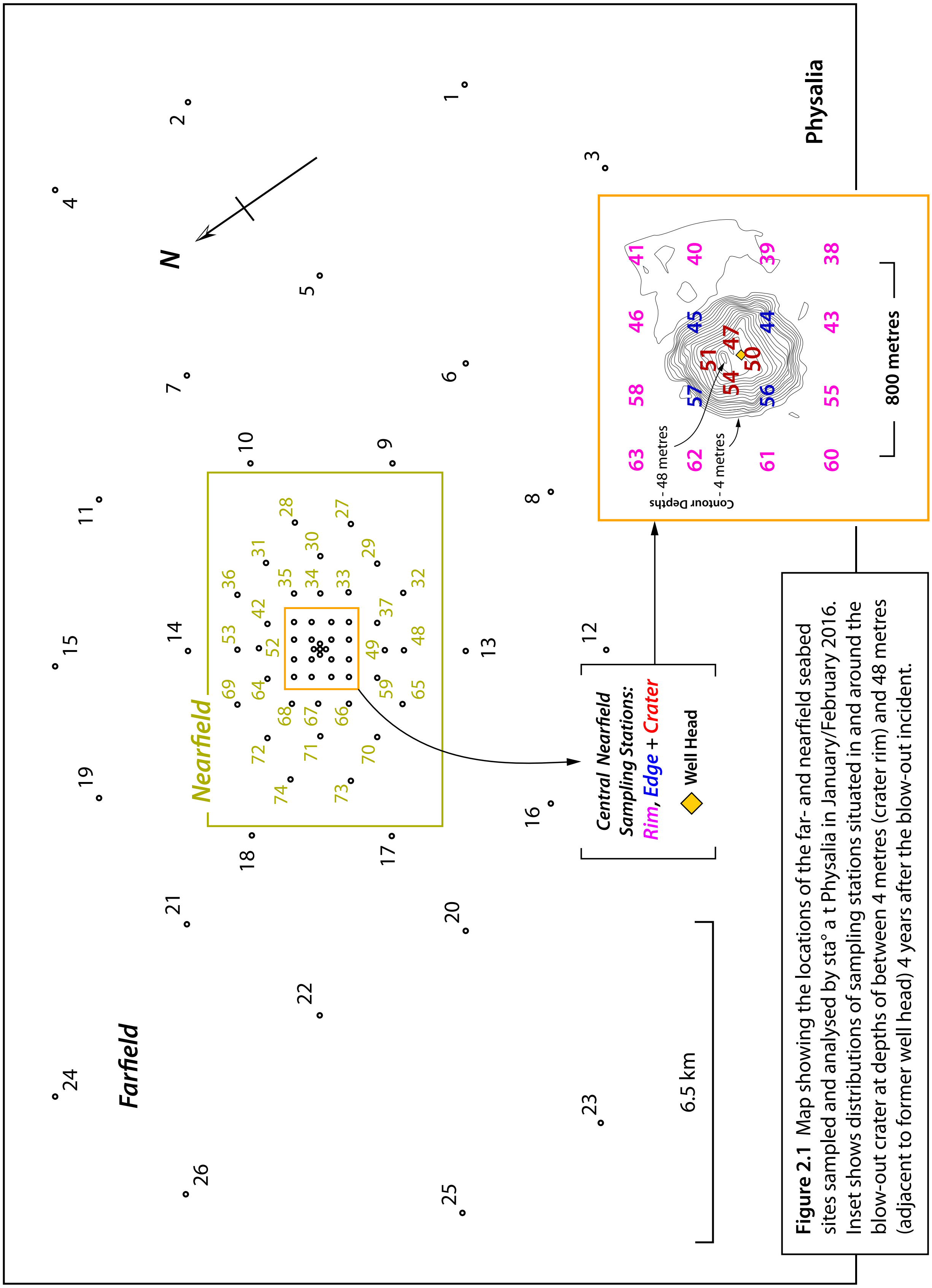

Figure 2.1 Map showing the locations of the far- and nearfield seabed sites sampled and analysed by sta° a t Physalia in January/February 2016. Inset shows distributions of sampling stations situated in and around the blow-out crater at depths of between 4 metres (crater rim) and 48 metres (adjacent to former well head) 4 years after the blow-out incident.

2 PROJECT DESIGN AND DATA ACQUISITION

Details of the field survey/sample collection and handling, laboratory methods and the subsequent analytical techniques applied to the data are presented in Physalia (2016a). Reference should be made to the previous report as needed.

The locations of the near-field and far-field sampling sites in relation to the former drilling platform are shown in Figure 2.1 and the coordinates of all sites that were sampled are presented in Table 2.1.

3 RESULTS

3.1 PRELIMINARY FIELD OBSERVATIONS7

Throughout the field survey, observations were made and recorded with respect to the nature of the benthic sediments. These included their appearance and colouration, presence of detritus and occurrence of larger invertebrate animals. Records also included water depth data, time of sampling and more notable variations in the granulometry of the samples collected. A transcript of the field notes is presented in Table H1 (Appendix H). Photographs of the sediment from each sampling site were also taken (see examples in Plates 2 to 4; Appendix G).

For verbal descriptions of the field observations, reference should be made to Physalia (2016a), Section 4.1.

3.2 SEDIMENT PARTICLE SIZE DISTRIBUTION (PSD) ANALYSES

The results of the sediment particle size distribution (PSD) analyses and the textural classifications for all 74 sampling sites are presented in Tables E1 and E2, respectively (Appendix E). The ranges of sediment types are also depicted graphically as a gravel/mud/sand triangle plot in Figure E1. The distribution of particle size fractions within the near-field survey grid is presented in Figure E2.

The results of the particle size distribution analyses of the far field sampling stations endorsed the findings of the nearfield samples reported in Physalia (2016a). Typically the background sediment granulometry of this section of the Bayelsa coast is dominated by silt and mud with < 63 µm particle size sediment fractions frequently exceeding 80% dry weight (see Table E1). The spectrum of sediment types recorded in the survey area is presented graphically in the textural triangle plot (Figure E1) whilst individual particle size fraction distribution plots are presented in Figure E5. The triangle plot emphasises the fact that the majority of the samples are located in the 'mud' and 'sandy mud' granulometric sectors. Three samples only were present in the muddy sand sector (identified as Sites 4, 36 and 51) whilst the remaining seven samples, comprising Sites 39, 40, 44, 45, 47, 56 and 57, were located within the 'sand' sector of Figure E1a and were classified as textural group 'slightly gravelly sand' (see Table E2). These latter coarse grained sediment sites were situated immediately adjacent to and within, the *KS Endeavor* crater.

As a means of characterising and demonstrating the variation in sediment composition types and their distributions within the near and far field survey areas, classification and ordination multivariate analyses were employed based solely on the particle size fraction distribution data. The results of the classification analyses are summarised in the form of a dendrogram in Figure E2 whilst the ordination results are expressed on the axial plot presented in Figure E3. The ordination analysis identified discrete clusters of samples based on the relative compositions of the sediment particle size fractions. Note that the largest grouping, Cluster A, encompassed 42 sampling sites and comprised the finest sediments with the < 63 μm fraction typically exceeding 90% (dry weight). Cluster B (16 samples) was characterised by 'sandy muds' where < 63 μm fractions exceeded 80% and the remainder of the sediment comprised mainly very fine sands (63 – 125 μm). Clusters C and D primarily 'sandy mud' samples with progressively higher proportions of medium (250 – 500 μm) and fine (125 – 250 μm) particle size fractions.

The classification analyses Clusters E, F and G represent sandy sediments with progressively higher proportion of coarser sand fractions, of which the coarsest sands were present in samples 44, 45, 47 and 57 (Cluster G).

The findings of the ordination analyses (see Figure E3) provided strong support for the results of the classification analyses. In this instance the clusters highlighted by the ordination techniques were represented by discrete clusters on the 2-axis ordination plot. This in turn provided a high degree of confidence in the patterns of mathematical relationships between the sediment particle size distribution (PSD) data and, hence, the relationships between the seabed sites that were sampled.

Figure E4 provides a summary of the distribution of the clusters of related seabed sediment types that were identified by the multivariate classification and ordination analyses within the near and far field survey areas. It can be seen that Cluster A and B sediments, coloured red and green respectively, prevailed at sites located further away from the former *KS Endeavor* site. These are the 'muds' and 'fine sandy muds' that represented the background conditions. Clusters C, D, F and G were located in closer proximity to the former centre of the blow-outs site and comprised increasingly coarser sediments. The coarsest of all the sediments (primarily sands), were identified at sites located at the *KS Endeavor* crater site and included the sampling stations 44, 45, 47 and 57, located at and within the blowout site.

The changes in the proportions of the sediment size fractions at each of the sampling sites is illustrated in Figure E5 (q.v.). Note the reduction in silts (< 63 μm sediment fractions) and the increased predominance of fine and medium sands (125 - 250 μm and 50 - 500 μm fractions) that can be seen readily by comparing their respective plots. Elevated proportions of the very coarse particulate fractions (500 to > 2,000 μm) also remained in the centre of the crater over 4 years after the incident. The persistence of the spatial patterns of coarser, sorted sediment fractions located within the blow-out crater, along with the considerably deeper seabed sediments that are still present at the epicentre of the incident, are indicative of on-going, active processes in the immediate vicinity of the *KS Endeavor* blow-out site.

3.3 SEDIMENT CHEMICAL ANALYSES

Chemical analyses of the sediment samples collected during the *KS Endeavor* residual impact assessment were carried out by Jones Environmental Laboratory. Their analyses were undertaken on *whole* sediments and did not involve pre-sieving. The full report is presented in Appendix I and should be referred to for site by site chemistry data.
Figures E6 to E22 (Appendix E) address the sediment metals and illustrate their spatial distributions on the seabed in the *KS Endeavor* near-field and, separately, in the far-field survey grids[1].

The distribution of sediment aluminium at sampling sites within the near and far field survey areas is presented in Figure E6. The plots show that seabed aluminium concentrations present at sites located away from the *KS Endeavor* and its associated blow-out crater were relatively uniform with slightly lower concentrations at the south western edge of the far field survey area and at Site 4, at the western extreme of the far field area. In contrast to these sites, sediments present at a number of sampling stations in closer proximity to the blow-out crater, namely Sites 39, 40, 44, 45, 47, 56 and 57, supported particularly low concentrations of aluminium, ranging from 507 mg/kg (Site 57) to 5,871 mg/kg (Site 47). These are in marked contrast to the survey area mean aluminium concentration of 34,142 mg/kg.

As reported in Physalia (2016a), distribution of sediment aluminium and the < 63 µm sediment particle size fractions are very similar (compare Figures E3 and E2; < 63 µm fraction, Physalia 2016a). Aluminium is present in the silt/clay fractions of most marine sediments in the form of alumino-silicates. Consequently, the close correlation between the < 63 µm sediment fraction and aluminium is as expected. Accordingly aluminium concentrations are low at the sandy sites in close proximity to the former *KS Endeavor* well head site (Sites 39, 40, 44, 45, 47, 56 and 57) and are elevated at the surrounding, silt-dominated sites.

Alumino-silicates are associated with clays and, hence, the < 63 µm sediment fractions. These fine silt-clay particles are characterised by negative surface charges and have the propensity to adsorb positively charged metal ions. Accordingly, the distributions of other metals, and in particular the transition metals, are commonly conspatial with those of aluminium. This was true for a number of metals in the present case and higher concentrations of chromium, copper, iron, magnesium, manganese, potassium, sodium, vanadium and zinc were recorded at the silt-dominated sites, whilst reduced concentrations of these metals and/or non-detects (i.e. concentrations blow the limits of detection) were associated with the sandy substrata (see Figures E11, E12, E14 to E17, E21 and E22, respectively). A few notable exceptions were observed. These included:

- **Chromium** (Figure E10); this element did not conform closely to aluminium and < 63 µm sediment fraction distribution patterns. A peak sediment chromium

[1] Note that the colours shown in the near- and far field metal/organic compound plots relate to the clusters of structurally-associated meiofaunal nematode bioindicator species identified in the multivariate analyses of their community structures. Refer to Appendix D for the results of the community bioindicator analyses.

concentration of 137 ppm was identified at Site 45, in well-sorted sandy substrata adjacent to the blow out crater;

- **Strontium** and **calcium** (Figures E9 and E20, respectively); these exhibited patterns that were consistent with the aluminium/< 63 µm fraction distributions within the nearfield survey area (see Figures E9 and E20, lower (nearfield) maps). However, the far field data for both elements showed markedly elevated sediment concentrations of strontium and calcium located to the south and south west of the survey area (see far field (upper) maps in Figures E9 and E20). These corresponded with sites of somewhat coarser sediments (when compared to background sediment granulometry at sites away from the *KS Endeavor* crater; see Figure E5 size fractions greater than 63 µm). Given that both strontium and calcium co-occur in mollusc shells at a ratio of approximately 1:100 (Sr:Ca, respectively), it is considered highly likely that the elevated concentrations of these elements were associated with fragments of shell debris in the slightly coarser sediments in this region.

As noted in the Physalia (2016a) report, a further anomaly was recognised in the sediment metal element data within the near-field survey area. This related to Site 62, located approximately 630 metres to the north-west of the former *KS Endeavor* well head. Here, the seabed substrata that were examined comprised a mixed, sandy mud with <u>*markedly* reduced aluminium concentrations</u> (10,360 mg/kg - as compared to the mean value of 34,143 mg/kg). Whilst this would have been expected to have yielded lower than average metal concentration loadings (arising from reduced alumino-silicate metal binding), the sediment metals at this sites yielded the highest concentrations for the following elements: arsenic (55.9 mg/kg), barium (1,292 mg/kg), cadmium (0.5 mg/kg), copper (133 mg/kg), iron (122,700 mg/kg), lead (894 mg/kg), manganese (1,022 mg/kg), mercury (0.3 mg/kg), nickel (55.6 mg/kg), vanadium (105 mg/kg) and zinc (372 mg/kg). This site also yielded the highest total organic carbon content of the sediment sampled, this being 5.49 %, as compared to the next highest value of 1.81 % at Site 24 and a mean of all sites of 0.95 %. The reason(s) for this anomaly cannot be determined with any certainty. However, given the close proximity of the sampling station to the *KS Endeavor* site, it is considered likely that the elevated metal loading of the sediment materials was associated directly with the blowout incident and might have reflected sorption of metals onto coarse sand fractions under the high temperatures and pressures arising from the blow-out incident.

As noted in sections above, the alumino-silicates (phyllosilicates) present in the form of fine, silt-clay sediment fractions have the propensity to bind negatively charged metal ions and localise these on the seabed. These ions comprise primarily transition metals that adhere readily to the surface-charged, clay/silt-clay fractions. Given the relatively close proximity of the marine survey area to the Nigerian estuarine waters and the coastal mangrove systems, it should be noted that relatively large quantities of terrestrial clay materials are exported regularly by rising and falling tides and accumulate at offshore sites. Through the process of adsorption, these fine clay particles carry with them their own unique combinations of sediment metals that ultimately settle offshore on the seabed.

The transport of estuarine/coastal contaminants to sea contrasts with the blow-out crater which supports its own, characteristic complement of transition metal elements and their concentration ratios. However, in this instance, silt-clays were not present in any significant

quantities in the coarse/sandy sediments in the vicinity of the crater. To address this, and to help visualise the patterns of distributions of above background concentrations of transition metals in the coarser grained survey areas, normalisation to aluminium has been used (see Figures E32 to E49; Appendix E). For further information on the value of normalisation to aluminium in metal studies in the marine environment, and for examples of its application in coastal studies, refer to Herut and Sandler, 2006; Ho *et al.,* 2012; Mahu *et al.,* 2016; Summers *et al.,* 1996; Schropp *et al.,* 1990. In the present study, sediment metal data were normalised to aluminium enabling 'above background' contributions of metal elements to be examined and described. The distribution maps for these data are presented in Figures 32 to 49 in Appendix E.

The combined near and far field distribution diagrams for the sediment metal data normalised to aluminium are presented in Figures E31 to E40 (Appendix E). In the majority of cases, the distribution of the normalised metal values indicate that sites in the vicinity of the blowout crater possessed above background concentrations of metals; see for example barium (Figure 32b), chromium (Figure 34a), copper (Figure 34b), iron (Figure 35a), manganese (Figure 37a), nickel (Figure 38b), vanadium (Figure 39b) and zinc (Figure 40a).
Normalised values for calcium (Figure 33a) and strontium (Figure 39a) exhibited an elevation above background in the central, crater zone and also at the south western extent of the far field survey area. As discussed above, this probably reflects the presence of shell debris in the sediments as both of calcium and strontium are characteristic components of mollusc shells. Shell fragments at and in the vicinity of the blowout area are less likely to have been dispersed during the blowout than the considerably lighter silt clay sediment fractions and, therefore, the relative concentrations of calcium and strontium would have become elevated when compared to adjacent habitats.

Analyses of sediment organic compounds failed to identify polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs) or semi-volatile organic compounds (SVOCs) at concentrations above laboratory reporting limits (see Appendix D). Dioxin and furan compounds were detected at all 74 sites located throughout the near- and far field survey areas. However, the presence and concentrations of these persistent organic pollutants (POPs) varied widely and several different concentration differing patterns were observed. Examples of these are presented in Figures E23 to E29 (Appendix E).

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Figures E23 and E24 present the distributions of the dioxin 123678-HxCDD and total 2378-dioxins, respectively. The distributions of these conformed to the patterns seen in the concentrations of the fine, < 63 µm particle size fraction and the aluminium distributions; compare Figures E23 and E24 with E5 and E6. This indicates that the concentrations of these persistent organic pollutants are associated with the fine silts as represented by the < 63 µm fraction and, by proxy, the aluminium concentrations.

The distribution patterns of the dioxin 123478-HxCDD is presented in Figure E25. This highlighted the fact that, with the single exception of Site 24 (at the north western extent of the far field survey area) all concentrations reported were above the laboratory reporting limits and were recorded either within the near field area (in the vicinity of the blowout sites) or to the east/south east of the blowout sites (i.e. the direction of prevailing, net current flow).

A similar distribution pattern was documented for the furan 23478-PCDF; see Figure E28. In this case the values above the laboratory reporting limit were all recorded either within the near field area or to the east/south east. The furan 2378-TCDF detects were also restricted to these areas. However, this compound was recorded only at concentrations above the laboratory reporting limit at five sites.

Figure E26 presents the distribution of the furan OCDF and revealed elevated concentrations in the immediate vicinity of the former *KS Endeavor* well head. These included Sites 40, 44, 45, 56 and 57 i.e. substrata present at the well-sorted sands associated with the blow-out incident and its resulting crater. This observation does not conform to the expected distribution of furans and dioxins as these were more strongly associated with distributions of fine silts.

Similarly, the furan 1,2,3,6,7,8-HxCDF yielded disproportionately high concentrations at a number of sandy sites in, and in the vicinity of, the blowout crater (see Figure E27).

As noted above for the sediment metals, dioxins and furans have a propensity to adsorb preferentially to the silt/clays fractions of sediment. However, these persistent organics differ from metals in that they adsorb to the organic carbon within the silt matrix rather than to the alumino-silicates present in clay (see Weber *et al*., 1983). Nevertheless, as a result of the affinity between dioxins/furans and the silts, the contamination from a point source may be obscured by any background contamination associated with fine sediments. To overcome this, the dioxin and furan data were normalised to aluminium, as per the metals. This was considered appropriate owing to the close correlation between sediment total

organic carbon values and sediment aluminium concentrations (see discussion on TOC, below).

The dioxin and furan concentration data, normalised to aluminium for the combined nearfield and far field survey areas, are presented in Figures E40b to E49b. As described for the metals, the normalised dioxin and furan data indicated concentrations above background levels in and around the *KS Endeavor* blowout crater for the majority of the congeners; see, for example, the furans 1,2,3,4,7,8-HxCDF (Figure 41b), 1,2,3,6,7,8-HxCDF (Figure 42a), 1,2,3,7,8,9-HxCDF (Figure 43a), Total 2,3,7,8 Furans (Figure 45a), OCDF (Figure 44b) and the dioxin 1,2,3,7,8,9-HxCDD (Figure 48a). Note: as described above, an elevation in the concentrations of the furans 1,2,3,4,7,8-HxCDF and OCDF in the vicinity of the blowout crater was also noted following examination of the raw, non-normalised data.

As reported in Physalia (2016a), the aliphatic and aromatic hydrocarbons detected in the chemical analyses were restricted to the heavier ranges, in both cases the C16 - C21 and C21 - C35 ranges. The spatial distributions of these sediment concentrations is summarised in the total aliphatic and aromatic compounds, the distributions of which are presented in Figure E30. The near field plot highlighted the low concentrations present at sandy sites in the immediate vicinity of the well head. These contrast with the organic compound sediment loadings that were recorded at adjoining, silt-dominated sites. A notable feature was the paucity of aliphatic and aromatic compounds that were detected in the far field area to the south west of the nearfield blowout zone. None of the sediment samples from Sites 1, 6, 8, 12, 13, 16, 17, 20, 23 and 25 yielded total aliphatic and aromatic compound concentrations above laboratory reporting limit.

Finally, the sediment total organic carbon (TOC) values are presented in Figure E31. As mentioned briefly above, a peak value of 5.49 % was recorded at Site 62, immediately adjacent to the blow-out crater. In comparison to all other sediment samples, this was an extremely high value, the next highest being 1.81 % at Site 24 (whilst the mean of all sites was 0.95 %). As reported above, in addition to TOC, the metals results for this site were also anomalous, yielding low aluminium concentrations and high concentrations of other metals (see text above for further discussion). In the light of these anomalous results, interpretation of the TOC data from Site 62 must be treated with caution.

Throughout the remainder of the sampling stations, the total organic carbon (TOC) values conformed largely to the distribution of the < 63 µm sediment fractions and the aluminium concentrations. This was to be expected as the fine particulate organic matter (FPOM) is associated strongly with the alluvial silt and, hence, the alumino-silicates of the clay fractions. As with the < 63 µm sediment fraction and the aluminium concentrations, TOC values were <u>low</u> at a number of sites in, and in the vicinity of, the *KS Endeavor* blowout crater; the TOC at Sites 44, 45 and 57 was below the limits of detection. Also, in parallel with the < 63 µm sediment fractions and aluminium, sites at the south west edge of the far field survey area supported TOC values that were lower than elsewhere in the far field (see Figure E31).

The spatial relationship between TOC and aluminium concentrations is demonstrated in the statistically significant, positive correlation coefficient (Pearson's *r*) between these parameters; the correlation coefficient being 0.466. By removing the anomalous result from

Site 62, that can be considered an 'outlier', the significance of the correlation coefficient increases markedly to 0.943, demonstrating a strong positive correlation between the two parameters.

In passing, it is for this reason that it was appropriate to normalise the sediment furan and dioxin data to aluminium in order to place the concentrations of these into context (see discussion above).

3.4 BENTHIC (SEABED) FAUNA

3.4.1 Macrofauna

a. Macrofaunal Univariate Analyses (Level I Analyses)

A total of 97 macrofauna taxa was identified in the near and far-field survey grid samples. The most abundant and diverse group of macrofauna animals was the annelids (segmented worms) which comprised 34 taxa, all of which were polychaete annelids (Class Polychaeta). A total of 32 mollusc taxa was recorded while the Biramia (crustaceans) accounted for 17 taxa. All other invertebrate macrofaunal groups were represented poorly.

Densities of macrofauna ranged from "none observed" (11 stations; see Table B1, Appendix B) to 34 invertebrates litre^{-1} sediment (Site 20). The distribution of macrofaunal densities is presented in Figure C1 (Appendix C). Details of the near-field grid demonstrate the low numbers of macrofaunal invertebrates present in the samples located in the central section of the survey area within, and in the vicinity of, the *KS Endeavor* site and the associated seabed crater. Within the nearfield survey grid there was generally lower species richness (number of taxa) at sample locations to the south east of the *KS Endeavor* site. Numerous samples collected in the immediate vicinity of the blowout site yielded no macrofaunal animals (e.g. Sites 38, 39 46, 47, 54 and 62) whilst others were represented by a single species (e.g. Sites 40, 41, 51 and 56; refer to Figure 3.1 for locations).

The far-field sampling sites presented Figure C1 (upper distribution map), demonstrate that, despite the occurrence of two sites at the south east edge survey grid that recorded no macrofauna (Sites 1 and 4), the species richness values of the far-field sites (Sites 1 to 26) were generally higher than those within the nearfield survey grid (Sites 27 to 74). This is emphasized by a simple comparison of the mean density values of the nearfield macrofauna samples (6.69 animals per litre sediment), with those of the far-field sites (14.92 animals per litre; shown to be statistically significant; $p < 0.001$).

Macrofaunal species richness values are displayed in Figure C2 (Appendix C) and are distributed in a similar pattern to the density values described above. Again, the majority of the low/depressed species richness values were observed in the central section and to the south east of the near-field survey area. As with the macrofaunal density data (with the sole exceptions of Sites 1 and 4), there was a general increase in the species richness values observed in the far-field sampling sites as compared to those of the near-field sites. The comparisons of the mean species richness values emphasise this with the mean species

richness for the near-field samples being 4.13 species whilst that of the far-field sites was 8.79 species. Again, these observations proved to be statistically significant ($p < 0.001$).

In terms of their density and species richness, the benthic macrofauna communities of the KSE area sampled during the 2016 survey are, overall, poor compared to other shallow coastal habitats. However, the data from the 2016 survey area indicate that the macrofaunal communities nearest to the former *KS Endeavor* platform, and at sites towards the south east, have not recovered to the background conditions described in the Physalia studies of the far-field macrofauna community assemblages.

b. Macrofaunal Multivariate Analyses (MVA - Level II Analyses)

Despite the inclusion of data from the additional 26 far-field sampling sites, it was not possible to apply ordination MVAs to the macrofauna data matrices. This was due to the overall low densities and low species richness values of the macrofaunal communities documented within the *KS Endeavor* survey area, and the occurrence of 11 sites at which no macrofauna was observed. Accordingly, the exploratory analyses were restricted to classification MVA assessment methods. The results of these analyses are presented in Figure D2 (Appendix D). The indicator species that defined the clusters of distinctive animal assemblages are listed in Table D1 (Appendix D).

The classification analyses identified 14 clusters of structurally-distinctive macrofaunal community types. The majority of the communities were allocated to mathematical Clusters I, J K and L which comprised 11, 9, 15 and 6 communities, respectively.

The remaining 8 clusters (Clusters A to H) were partitioned from Clusters I to L at the first level of division. Clusters A to H comprised at total of 22 communities and represented structurally fragmented communities.

The multivariate classification dendrogram relating to the distribution of the species present (Figure D1; vertical dendrogram), and the species density matrices, indicate those species that were associated with each sample assemblages and the combination of species responsible for 'similarity' of the assemblages within each of the clusters. It is apparent that a cluster of six similarly distributed polychaete species (*Diapatra neapolitana* (code 1), *Mediomastus* species (code 4), pectinariid species (code 2), *Notomastus* species (code 8), cirratulid species (code 7) and *Nephthys sphaerocirrata* (code 11)) were largely responsible for separating Clusters I to K from the remaining assemblages. Indeed, the table of macrofauna indicator species (Table D2) identifies the distribution of pectinariid species, *Notomastus* species and *Nephthys sphaerocirrata* as being statistically significantly related to Clusters I, J and K, respectively.

With the exception of Sites 45 and 56, which were grouped together as Cluster G due to the co-occurrence of a *Magelona* species (code 16), the sites in the immediate vicinity of the *KS Endeavor* blowout site did not form discrete, characteristic clusters of similar assemblages. This is unsurprising as many of the samples collected from this area comprised very few, or no, macrofaunal animals (see macrofauna univariate discussion above).

Despite the differences in the structure of the macrofaunal assemblages identified by the multivariate classification analyses, there was no consistent, clear pattern in the distribution of the community 'types' beyond the seabed in the vicinity of the *KS Endeavor* blowout crater site. Despite the far-field macrofauna samples being on average, more abundant and diverse than the nearfield samples, no characteristic 'background' community type could be identified and defined. This is probably a reflection of the general paucity of the macrofauna densities and diversities that occurred within the area surveyed.

3.4.2 Meiofaunal Nematoda

In addition to nearfield meiofauna samples that were separated, identified and analysed for the Physalia (2016a) report, the 26 far-field samples were subsequently prepared for examination. Strict quality assurance procedures were applied for the collection, preservation, storage, separation and preparation processes of the meiofauna samples. This included ensuring that the samples were maintained under optimum conditions prior to the separation procedures.

During the inspection of the samples prior to the commencement of the far-field meiofauna separations it was noted that the container for Sample 20 had been damaged, presumably during freighting/transit from Nigeria to the UK. This had resulted in the loss of supernatant fluid and the sediment sample had dried out. As some meiofaunal specimens had probably been lost and the conditions of the remaining meiofauna may have been compromised through drying out, this sample was discarded in accordance with the Physalia quality assurance guidance.

a. Nematode Univariate Analyses (Level I Analyses)

The taxonomic species list for the meiofaunal nematodes recorded in the *KS Endeavor* residual impact assessment survey is presented in Table A2 (Appendix A). The site-by-site results are presented in Table B2 (Appendix B). A total of 160 taxonomically discrete nematode taxa/species was documented within the near- and far-field sampling stations. Of these, 37 species were unique to the far-field sampling sites.

The total densities of nematodes varied widely throughout the survey area ranging from a maximum of 14,848 nematodes litre^{-1} sediment at Site 53 to only 9 nematodes litre^{-1} at Site 51, within the *KS Endeavor* blowout crater.

Figure C4 (Appendix C) presents the distribution of the nematode community density data across the near-field and the far field survey areas. The lowest densities of nematodes occurred at three of the four sites situated immediately adjacent to the former well head (i.e. within the crater that formed during the 2012 blowout incident). The density values of 9, 16 and 36 nematodes litre^{-1} for Sites 51, 50 and 54, respectively, are considered to be extremely low for naturally occurring marine benthic nematode communities. The remaining sample collected from the crater also displayed reduced nematode density with

only 248 nematodes litre^{-1} being recorded, compared to the survey average of 2,867 nematodes litre^{-1}.

Conversely, the six sites located around the periphery of the crater and to the south east, comprising Sites 39, 40, 44, 45, 56 and 57, yielded density values that were above average nematode densities for the near and far field survey area sediments and ranged from 4,577 nematode litre^{-1} (Site 45) to 10,894 nematodes litre^{-1} (Site 39). These samples were derived from sites characterised by sandy substrates as opposed to the fine, silt-dominated deposits present elsewhere in the survey area (see Sections 3.1 and 3.2 for substrate descriptions). It should be noted however, that, whilst these samples revealed higher than average densities, the species richness values were below the survey average.

Beyond those sites described above, the nematode density distributions throughout near- and far-field survey area did not conform to a clear, consistent spatial pattern. Unlike the aforementioned macrofaunal communities, there was no significant difference between the mean densities observed in the far-field samples when compared with those of the nearfield. This indicated a more rapid recovery of the meiofaunal nematode communities than that of the macrofaunal size class.

The distribution of nematode species richness values (total numbers of species per sample) is presented graphically in Figure C3 (Appendix C). Species richness of the nematode assemblages also varied considerably throughout the survey area, ranging from a single species at Sites 51 up to 42 species at Site 16 (the full survey average being 20.8 species). Extremely low values were recorded in the immediate vicinity of the former *KS Endeavor* well head, with Sites 51, 50 and 54 supporting 1, 2 and 3 species respectively. This, combined with the aforementioned low densities at these sites, is considered *extremely unusual* for undisturbed, uncontaminated marine sites and indicated the existence of a source, or sources, of environmental stress.

As described for the density data above, there were no clear and consistent patterns within the nematode species data beyond the vicinity of the blowout site. Similarly, unlike the macrofauna communities, no statistically significant difference was detected between the mean species richness values of the far-field samples compared with those of the nearfield. Dominance, the percentage abundance of the most abundant species is a simple but valuable community parameters. When stressed, either as a result of anthropogenic influences or due to inhospitable natural conditions, the species that are able to tolerate the conditions proliferate whilst those that are sensitive to the stressor(s) decline in abundance or are eliminated from the habitat. Accordingly, sites with elevated community dominance values are likely to be subject to environmental stress. The dominance the *KS Endeavor* near- and far-field grid are presented in Figures C6 (Appendix C). Whilst these further demonstrate the modified communities that were recorded at and in the vicinity of the former *KS Endeavor* well head (see the high dominance at the crater sites 47, 50 and 51), care must be taken when interpreting dominance data from very depauperate communities such as these as the very low species richness and densities can lead to disingenuous percentage dominance values.

Simpson's diversity index is a derived community parameter that incorporates both species richness and evenness (the distribution of individuals amongst the community's

component species) to indicate the overall 'diversity' of the site; high diversity values indicating low environmental stress and low diversity values indicating high environmental stress. The nematode community diversity data for the *KS Endeavor* near- and far-field survey areas (see Figure C7) conform largely to the patterns observed and described for the density, species richness values and dominance values. Low diversity values were recorded for samples from sites in the immediate vicinity of the former well head. These comprised Sites 47, 50, 51 and 54 (diversity values 2.4, 2.0, 1.0 and 2.8, respectively) and indicated the operation of environmental stress at these sites.

Other low diversity values were associated with the MVA Cluster M communities (Sites 14, 67, 30, 32, 22, 38 and 48); see sites highlighted in dark green in Figure C7. These Cluster M communities are located throughout the near and far field survey area and display no apparent pattern or association with the *KS Endeavor* site.

The investigations described in the present report include assessments of the meiofaunal nematode "trophic ratios". These ratios highlight the relative proportions of species that possess large, unarmed mouths and that feed non-selectively on deposits of fine detritus (microbe-rich, decomposing organic material; i.e. Type 1B species) and those species that possess small armed ("toothed") mouths and that feed selectively on microbial epigrowth present on sand grains or on diatoms (i.e. Type 2A species). The value of this approach lies in the ratios of Type 1B to Type 2A nematode species as these indicate habitats with fundamentally different physical characteristics and/or food resources. The 1B/2A ratio is employed widely by meiobenthologists to detect spatial and temporal changes in environmental conditions (see Lambshead, 1986 and Trett *et al.,* 2009).

The nematode trophic ratios are presented graphically in Figure C6. This distribution plot highlights elevated trophic ratios in close proximity to the former *KS Endeavor* well head and demonstrates modified community structures at these sites when compared to the majority of the nematode assemblages throughout the survey area. Under normal circumstances, it would be expected that, where sandy substrates occur, the proportion of the type 2A species would increase whilst, conversely, the proportions of type 1B species decrease, resulting in a reduction in the trophic index. It was apparent that the opposite had occurred at a number of sites in the vicinity of the *KS Endeavor* blowout site (see Sites 44, 47 and 56). This is due in part to the unusual array of species that occupy the silty sediment of the survey area. It is generally expected that mud and silt habitats will favour primarily Type 1B, non-selective detritivores. However, within the survey area muds, small-mouthed *Terchellingia* species (family Linhomoeidae; see species codes 35 to 39) were common. These conform to the Type 1A feeding type (small, unarmed mouths) and do not contribute to the 1B:2A feeding type ratio. Also common in the mud was the species *Comesa* species 1 (code 15). This is categorized as a Type 2A species and therefore serves to reduce the ratio value. Conversely, at the sandy sites in the vicinity of the blowout crater, the sediment had been colonized by species tolerant of the modified conditions, including *Rhynchonema* species (code 56) and *Xyala* species (code 61). These species possess open, unarmed mouths and are categorised as Type 1B species and, hence, result in increased feeding type ratio values.

Despite these apparent anomalies with regards the expected trophic structure of the nematode communities of the sandy and muddy sites, the feeding type ratios further

demonstrate the modification of the benthic communities that is associated with the *KS Endeavor* blowout incident.

b. *Nematode Multivariate Analyses (MVA, Level II Analyses)*

The multivariate analysis of the nearfield meiofaunal nematode community data was presented and described in the previous, Physalia (2016a) report.

Following the completion of Physalia (2016a) survey report, the fauna of the remaining 26 far-field sampling sites were analysed. The data were added to the nearfield nematode community data and the full sets of mathematical analyses were re-run. The results of the near- and far-field classification analyses are presented in Figure D2 whilst the results of the ordination analyses are presented in Figure D3a (showing the sample site numbers) and D3b (displaying the association of individual species with the community clusters). The distribution of the clusters of nematode assemblages with similar community structures (as identified by the MVA) within the near and far field survey areas is presented in Figure D4. The indicator species that exhibit statistically significant associations with given cluster of nematode communities are listed in Table D3.

The vertical classification dendrogram presented in Figure D2 indicates the similarities between the assemblages of nematode species that occur at each of the near- and far-field sites (see interpretation guide; Table D1). The nematode samples from each sampling site are grouped into clusters of structurally similar assemblages. The analyses identified 15 distinct/discrete groups, labelled A to O. Clusters A to D are located on the upper half of the dendrogram and comprise 46 of the 73 nematode assemblages analysed. These are linked with the remaining 27 assemblages at a low level of similarity (note the "height" of the links). Clusters E to O comprise a heterogeneous group of community types, including seven samples that had assemblages that were not sufficiently similar to any other sample to enable grouping. Accordingly, these were identified as single site clusters or 'outliers'.

Reference to the ordination diagrams presented in Figure D4a and D4b and the classification analysis dendrogram (Figure D2) demonstrates a strong similarity between the results of the two sets of fundamentally different multivariate analyses. The principal clusters identified by the classification analyses are closely replicated by the results of the ordination analyses. It should be noted that the first two axes of the ordination accounted for <u>over 84 % of the total statistical variance within the nematode community data</u>. Consequently, a high degree of confidence can be placed on the results of these analyses as the possibility that the results are achieved by chance is minimal.

The horizontal classification dendrogram presented in Figure D2 represents the similarity in the distributions of the individual nematode taxa (i.e. species/taxa) within the 73 meiofaunal samples analysed. The species density matrix below the dendrogram identifies the samples in which each species occurred and indicates the relative abundance (numbers per litre sediment) of species present in each sample. Displaying the species data in this

manner enables the characteristic compliments of species associated with given community clusters to be identified.

For community Clusters A to D, the majority of the species are located at the left-hand side of the horizontal species dendrogram (seen clearly in the meiofaunal nematodes clustered on the dendrogram between species 4 and species 32). Using this approach, individual species/combinations of related species have been identified that define and typify nematode communities associated with the Bayelsa coastal benthic habitats. These were characterised by the most common species recorded in the survey including *Comesa* species (code 23), *Terchellingia* species 1 (code 36), species 2 (code 37) and species 3 (code 38), *Terchellingia longicaudata* (code 35), *Vasostoma* species (code 12) and *Metadesmolaimus* species (code 43); note the close clustering of these species' codes on the horizontal, species dendrogram.

Further details of the key species for these clusters are given in Table D3 which also identifies the mathematical indicators that are statistically significantly associated with given clusters of nematode communities.

The remaining clusters (E to O) deviated significantly from the characteristic community structural patterns of Clusters A to D, both in species composition and the relative abundance of the component species.

Cluster O represented a distinctive community type that occurred in the immediate vicinity of the *KS Endeavor* blowout crater. This comprised Sites 40, 44, 45, 56 and 57. These were characterised by fine to medium sand substrates (see Section 3.2, for discussion of particle size distributions) and contained indicator species that were found to be present almost exclusively at the five sites within this group and represented a community type that deviated markedly from those of the surrounding habitats.

Seven nematode communities were classified by the multivariate analyses as being dissimilar to those of all other sites leading to the establishment of single-site clusters (see Figures D2 and D3a and b). Of these, Sites 47, 50, 51 and 54 samples were retrieved from the deep water (40 m – 45 m) within the *KS Endeavor* crater. These sites supported particularly low densities of meiofaunal nematodes with few species being represented (see Table B2, Appendix B, and density and species richness plots, Figures C1 and C2, Appendix C). In the case of Sites 50, 51 and 54, the nematodes were represented by 2, 1 and 3 species, respectively. The Site 47 community comprised 8 species. These low densities and low species richness values (and, hence, high dominance values) led the analyses to identify these samples as 'outliers'. As noted previously, these species richness values are extremely low for naturally occurring coastal benthic nematode assemblages and indicate the operation of chronic and/or on-going environmental stress/stresses.

The remaining single sample, 'outlier' clusters were present at Sites 11, 26 and 39. Sites 11 and 26 were muddy sites located in the far-field survey area and revealed communities with low densities and species richness values. As with Sites 47, 50, 51 and 54 discussed above,

this is unusual and indicates environmental stress, the cause of which, in the case of these two sites, remains uncertain.

Site 39 (Cluster D) was a sandy substrate and the nematode community comprised high abundances of *Pseudosteineria* species (code 120; see Plate 5D) and *Marylynnia* species (code 103) that occurred in low densities only at a few other sites, respectively and three other species unique to Site 39.

3.4.3 Meiofaunal Harpacticoid Copepoda

a. Harpacticoid Copepod Univariate Analyses (Level I Analyses)

The harpacticoid copepods (small, shrimp-like crustaceans) are usually highly abundant in marine sediments. However, in the samples collected from the *KS Endeavor* near- and far-field sampling grid, this group was, for the most-part, represented particularly poorly. A total of just 17 taxa was identified representing three copepod families only. At more than half of the sites examined (i.e. 34 out of 73 sites), no copepods were recorded at all. Single species only were observed at a further 21 sites.

The distribution of the copepod assemblages in terms of their species richness values and total densities are presented in Figures C8 and C9, respectively. This demonstrates the paucity of the copepod assemblages throughout the survey area. Figure C8 and C9 also indicated that, where they do occur, the copepods were most prevalent in the centre of the survey area (in the vicinity of, *but not in*, the *KS Endeavor* blowout crater) and, again, to the south west of the far-field area. These areas correspond with sandy substrates and muds with a higher than average fine/very fine sand content (compare Figures C8 and C9 with C5; Appendix C).

The peak copepod density occurred at Site 44 where 1,223 copepods litre^{-1} were recorded with Site 45 yielding 666 copepods litre^{-1}. This reflected the colonisation of the sand habitat by two species belonging to the family Ectinosomatidae (codes 8 and 9) and a Diosaccid species (code 11) that occurred exclusively at Sites 44, 45, 56 and 57, i.e. at sites located adjacent to the *KS Endeavor* blowout crater. Within the crater itself, no copepods were recorded.

b. Harpacticoid Copepod Multivariate Analyses (MVA, Level II Analyses)

Due to the paucity of the harpacticoid copepod present in the samples from the near and far field survey grid, it is not considered appropriate to apply multivariate analytical technique to the copepod community data set.

3.5 MULTIVARIATE CORRELATION ANALYSES (ARESC; MEIOFAUNAL NEMATODA)

In the previous Physalia (2016a) document it was noted that the low diversity and species richness values of both the macrofauna and the meiofaunal copepod communities and the number of sites failed to yield representatives of these faunal groups, rendered their

respective data sets insufficiently robust to enable statistically valid multivariate correlation (ARESC) analyses to be undertaken. Following the inclusion of the far-field data, the complete data matrices for these groups still remained insufficiently robust and precluded the application of the multivariate correlation analyses. However, the meiofaunal nematodes species and their communities collected from the near and far field sampling sites remained sufficiently abundant to support the multivariate correlation ARESC analyses. The results of the nematode ARESC analyses are summarised graphically in Figure F1 (Appendix F) and the associated data tables are presented in Table F1.

It should be noted that, due to the requirements of the multivariate correlation techniques employed here, full "sets" of physico-chemical parameter values were required for all samples. Therefore, where values for some parameters were not available (e.g. values below the laboratory limit of detection = 'non-detects'), this precluded the inclusion of that particular physico-chemical in the ARESC analyses. The single exception to this was the percentage total organic carbon (TOC). Sites 39, 44, 45 and 57, recorded TOC values below the limit of detection. In these cases, imputed, 'nominal' TOC values of 0.02 % were applied to enable the correlation of this valuable environmental parameter to be included in the ARESC analyses. Note that for technical reasons the correlation coefficient for the TOC values *is* included in the ARESC table (Table F1) whilst it is excluded from the ARESC ordination plot itself Figure F1.

Figure F1 presents the meiofaunal nematode ordination plot, described previously in Section 3.5.1. Superimposed on the ordination plot are correlation vectors ("lines") for each of the physico-chemical parameters (i.e. particle size fractions and chemical concentrations) for which suitable data were available. In each case, the length of the correlation line corresponds to the strength of the correlation of the respective parameter and the direction of the line indicates the axis/axes, and hence the nematode communities, with which given parameters are correlated.

In terms of the structures of the nematode assemblages that occurred at each of the far and near field sites, Axis 1 (the distribution of communities (sampling sites) from left to right) was the most important and accounted for nearly 60 % of the total variance in the nematode community data set. Therefore, correlations aligned with this axis indicate the strongest association between the physico-chemical parameters and the structures of the nematode communities.

The longest correlation lines were associated with Axis 1 and related to a range of metal concentrations (Mn, Fe, Al, Mg, V, Ni, K and Na), aligned in the positive direction of Axis 1 and the particle size fractions 125 - 250 µm (fine sand), 250 - 500 µm (medium sand) and 500 - 1000 µm (coarse sand), aligned in the negative direction of Axis 1. This indicates that these parameters are most closely associated with variation in the structure of the nematode species assemblages. Also aligned with Axis 1 but with shorter correlation lines were the < 63 µm silt/clays, barium and a suite of dioxins and furans (labelled "Chem 166, 172, 173 and 174).

Given the observed variation in the sediment type associated with the *KS Endeavor* blowout site (see Section 3.2), these associations with the benthic faunal are not unexpected. Under natural conditions, sediment type is the key factor that determines the structure of benthic

communities and, hence, any anthropogenic disturbance that alters the sediment granulometry will, in turn, affect the structures of the communities. The ARESC diagram indicates that the samples positioned to the left of the plot are associated with the sandy sediments whilst those to the right are associated with fine, siltier sediments. The distribution of the metals noted above extending to the right supports this and, as noted in Section 3.3 above, the orientation of the correlation vectors reflect the metal ions tendency to adsorb to the alumino-silicates associated with the fine clay fractions.

In contrast, the furans and dioxins are not naturally occurring. Classified as persistent organic pollutants (POPs), these include highly toxic, persistent congeners. These form primarily during combustion of organic material and/or organic compounds in the presence of chlorine or chloride ions and oxygen (Addink and Olie, 1995) with or without the presence of metal chlorides and oxides acting as catalysts (Kuzuhara, 2003; Zhang *et al.*, 2016). They are similar to metals in that they accumulate in fine silty sediments, however, unlike metals, dioxins and furans adsorb preferentially to the organic carbon sources present in sediments as opposed to the alumino-silicate clays (Weber, 1983).

The Cluster O communities arise from locations in the immediate vicinity of the *KS Endeavour* blowout crater. These were the well-sorted sands and, consequently, are located at the extreme left-hand side of the ARESC plot demonstrating a close association with the fine, medium and coarse sand fractions.

In terms of the meiofaunal nematode bioindicator species assemblages, the majority was located to the right of the centre of the ARESC plot. This indicated an association between distribution of the finer sediments and their associated organic compounds and metal elements.

The correlation lines exhibiting relationships with ARESC Axis 2 were shorter than those aligned with Axis 1, indicating lesser coefficients of correlation with the vertical distribution of the sample communities. Nevertheless, the parameters that were most closely associated with ARESC Axis 2 were the sediment particle size fractions 63 - 125 µm, 1000 - 2000 µm and >2000 µm, in the positive direction. Clusters C, E and the majority of the large Cluster D were displaced to the positive side of ARESC Axis 2, indicating correlations with these sediment grain size fractions. In contrast, the correlation lines for chromium and the dioxin 1234678-HpCDF (Chem 163) were aligned in the negative direction along Axis 2, corresponding with the positioning of the bioindicator community Clusters K and M as well as the majority of Cluster A.

It should be noted that care needs to be taken when interpreting the locations of the 'outlier' communities within the ARESC ordination plots and the association with the measured physio-chemical parameters. In most cases, these relate to very depauperate nematode assemblages with very low species richness and/or very low nematode densities (see for example, the assemblages from the *KS Endeavor* crater; Sites 47, 50 51 and 54). Accordingly, distinctive 'patterns' of community structures within these assemblages cannot not be ascribed.

The ARESC table (Table F1; Appendix F) presents the statistical significance data for the correlations between the physico-chemical parameters and the two ordination axes. The

parameters have been ranked in order of the strength of their correlation with respect to the bioindicator community structure axes. The parameters highlighted in red represent the highest level of statistical significance ($\alpha < 0.01$) whilst the parameters highlighted in orange are statistically significant with an α-value of < 0.05.

The correlation table corroborates the associations between the nematode community structures within the near and far field survey areas and the measured physico-chemical parameters indicated by the ARESC ordination plot described above. The strongest correlations for Axis 1, indicated by the higher coefficients of correlation, were associated with the metals manganese, iron, vanadium, magnesium, aluminium and potassium. Other metals, including nickel, sodium, barium, calcium and chromium also demonstrated strong association with the nematode community distribution along Axis 1. A number of these metals, including aluminium, manganese, nickel and iron, are common components of laterite soils and would be expected to occur in sediment dominated by alluvial input such as occur off the Bayelsa coast. However, elements such as vanadium, chromium and barium would not be expected to arise from natural terrestrial sources in significant quantities. It should, however, be held in mind that barium is a common constituent of drilling muds used to during the construction of oil and gas wells.

Also correlated strongly with the nematode community distribution along Axis 1 were the particle size fractions 125-250 μm, 250-500 μm, 500-1000 μm (negatively correlated) and <63 μm (positively correlated) as well as total organic carbon (positively correlated).

It is also noteworthy that strong correlations between the two dioxins congeners, 1234678-HpCDD and OCDD and, separately, total 2378 dioxins were documented, confirming the association between these persistent organic pollutants and the structures of the nematode communities indicated by the ARESC ordination plot, as discussed above.

The ARESC analyses described above indicate that the primary influence on the structure nematode communities of the near and far field survey areas *at the time of the 2016* survey was sediment type. The sandy substrates associated with the blowout crater were associated with distinct nematode communities that correlated with the sand fraction. Conversely, the fine sediments, as indicated by the < 63 μm fraction, the aluminium concentration and the TOC were associated strongly with nematode communities away from the *KS Endeavor* site.

Also associated with the sediment type and the structure of the nematode communities was the distribution of chemical parameters including metals and dioxins. Whilst it is likely that the distribution of these is influenced strongly by the sediment type (metal adsorbing to alumino-silicate clays and dioxins adsorbing to organic carbon) a causal effect between these parameters and the meiofaunal nematode communities cannot be dismissed.

4 EVIDENCE OF RESIDUAL IMPACTS

The Physalia (2016a) report presented the evidence of residual impacts relating to the *KS Endeavor* blowout and subsequent fire on the benthic habitats and invertebrate communities present in the near field survey area only. This area extended to approximately

2.7 km from the former *KS Endeavor* well head site. During the field survey, samples from an additional 26 far field sites were collected, extending the area that was assessed to approximately 12 km from the former well head. Due to time constraints relating to initial submission of evidence, the far field samples were neither analysed for, nor reported in, the Physalia (2016a) document. As a result, discussions considered only sampling sites in the proximity of the blowout site. Comparisons with further afield, 'background' conditions were not possible and this inevitably constrained the conclusions that could be drawn.

The following section discusses the evidence relating to residual impacts of the *KS Endeavor* blowout incident on the seabed by considering data from both the near and far-field sampling sites. References are also made to related reports that provide information on seabed conditions.

4.1 SEABED AND SEDIMENT

The side scan sonar survey works undertaken during the 2016 fieldwork and presented in the Irish Hydrodata (2016) document, demonstrated the presence of a large crater, approximately 500 m in diameter and 50 m in depth. This persisted at the *KS Endeavor* site four years after the blowout incident. The dimensions of the crater, determined by Irish Hydrodata (2016) are very similar to those described by the Chevron Nigeria in January 2013 (see report entitled *Seabed Survey of Funiwa Deep A Post Fire Scene - Seabed Investigation*) and is presented in *Environmental Accord* (2015). This indicated that little or no-infilling had occurred during the intervening three years.

The volume of the blowout crater, as at January 2016, was approximately 4,500,000 m^3 (Irish Hydrodata, 2016). This signifies that, as a minimum, an equivalent volume of material was displaced during the formation and subsequent active maintenance phases of the crater. It is implausible that the deposition of such quantities of material, ranging from very fine silts to coarse sands (see results of Physalia particle size analyses results; Section 3.2), onto the surrounding seabed did not result in an expansive impact on the benthic faunal communities. As discussed above and outlined briefly below, four years post-incident, the residual impact on the benthos is still discernable.

The sediment particle size (granulometric) analyses and the distribution of different sediment 'types' is discussed in Section 3.2. The majority of the near and far field survey area is characterised by the presence of "fine sediment dominated" muds and sandy muds with proportions of < 63 µm fractions typically exceeding 80% dry weight. This contrasts with the sediments collected at and in the vicinity of the blowout crater. Here sandy substrates were present. The coarsest sands were collected from sampling sites 44, 45, 47, 56 and 57, adjacent to or located within the blowout crater, which yielded < 63 µm sediment fractions of 0.00, 0.00, 4.21 and 0.47%, respectively. As outlined below, the changes in the sediment granulometry associated with the blowout crater resulted in a significant modification to the benthic fauna that has persisted up to the most recent investigation.

In addition to the sand substrates documented in Section 3.2 and described above, sediments from six sites surrounding the blow-out crater of the former *KS Endeavor* well head yielded sands that were present as thin layers overlying fine, silt-dominated sediments

(see photograph of undisturbed sediment grab sample in Plate 4 (Appendix G); field notes transcripts in Table H1 (Appendix H) and discussion presented in Physalia (2016a) Section 4.1). These observations were documented independently by Chevron representatives (Environmental Accord) during the fieldwork. Had these sands been deposited during the initial blowout and fire incident in 2012, these coarser grained materials would have been covered by alluvial silts that emanate from the coastal Delta and would have been incorporated with the silt substrata. The fact that sands were clearly evident on the surface of the sediments at sites surrounding the crater during the January/February 2016 field survey indicates that sands had been deposited within this area in the recent past. Given that the only rational source of sands located in this region would have been the *KS Endeavor* blowout crater itself, these observations indicate that sporadic displacement of sands from the crater is still occurring. This, in turn, could have occurred only if there had been significant quantities of gas emitted through the sandy substrata within the crater beneath the former well head site.

4.2 SEDIMENT CHEMISTRY

The results of the sediment chemistry analyses are described in Section 3.3. With the exception of chromium, strontium and calcium, the distribution patterns of the majority of metal concentrations conformed to the distributions of fine silt/clays (< 63 µm sediment size fraction) and the clay-related aluminium. As discussed in Section 3.3, this is not unexpected as the clay fraction alumino-silicates adsorb positively charged ions and readily 'bind' metals. However, with the application of normalization techniques to determine where concentrations of sediment metals are *above background levels* demonstrated that at, and in the vicinity of, the blowout crater, higher than expected levels of metals occurred. This indicated a residual 'chemical footprint' associated with the blowout incident that is still discernable four years after the blowout incident.

The persistent organic pollutant (POPs), dioxins and furans, are formed during the combustion of organic carbon compounds in the presence of chlorine or chloride ions (see Addink and Olie, 1995; Kuzuhara, 2003; Zhang *et al.*, 2016). Given the temperature-pressure conditions that would have been generated by the blowout, along with the subsequent fire, it is highly likely that these compounds could have been formed *in situ*. Figures E23 to E29 show the distributions of the raw (non-transformed) dioxin and furan sediment data.

The dioxin congener 1,2,3,6,7,8-HxCDD and the total 2,3,7,8-dioxins were distributed in a spatial pattern that was consistent with the silty muds (< 63 µm silt/clay sediment fractions) and, by proxy, the aluminium concentrations. However, unlike the sediment metals described above, dioxins and furans have a propensity to bind to particulate organic carbon associated with the silty muds rather than to the alumino-silcates of clay (see Weber *et al.*, 1983). This close association with the fine sediments can preclude the source of the pollutants from being discerned using raw data alone.

However, evidence that the *KS Endeavor* blowout incident was the source of persistent organic pollutants was provided by the distribution of the furans OCDF *and* 1,2,3,6,7,8-HxCDF. As noted above, these compounds have the propensity to adsorb to the particulate organic carbon present in the silt-dominated sediments. Accordingly, where comparatively

low quantities of silt were observed in the sediments, it would be expected that the furan concentrations would decrease proportionately. The furans OCDF and 1,2,3,6,7,8-HxCDF were recorded at disproportionately *high concentrations* at the sandy, low silt sites in, and in the vicinity of the *KS Endeavor* blowout crater.

The raw data distribution patterns of other dioxins and furans provided further evidence that the *KS Endeavor* blowout incident was a source. The dioxin 1,2,3,4,7,8-HxCDD and the furans 2,3,4,7,8-PCDF and 2,3,7,8-TCDF were all (with a single site exception of the former compound at one site) detected in the nearfield sediment and to the east of the *KS Endeavor* site, in the prevailing direction of the water current and the direction of dispersion of crater materials as indicated by the side scan sonar survey (see Walsh, 2016). This provided strong evidence that the blowout site was the source of these compounds and that they were disseminated and broadcast across the seabed with the materials ejected from the crater.

As with the metals data discussed above, the association of dioxins and furans with the fine sediments can mask the above background levels of these compounds and the sources of these POPs cannot be determined readily using raw data alone. To overcome this, the dioxin and furan data were normalised using aluminium as a proxy for the organically-enriched alluvial silts. The normalised data indicated the presence of above background concentrations of a range of dioxins and furans in close proximity to the *KS Endeavor* crater, thereby implicating the blowout incident as the primary source for the generation of these persistent, highly toxic organics.

In addition to the mobilisation and re-distribution of sands, demonstrated clearly by the results of the Physalia 2016 survey sediment granulometric analyses, the blowout incident would have resulted inevitably in the mobilisation and re-distribution of the fine, silt/clay fractions. These lighter (lower density) sediment fractions, would have been disseminated and broadcast over a greater distance than the coarser, heavier sediment (= sand) fractions.

As discussed in Section 4.3 above, the silt clay fractions are characterised the presence of alumino-silicates. These particles are negatively charged and have the propensity to adsorb positively charged metal ions. Given the above, it is likely that the metal contaminants that were liberated during the blowout incident would have migrated with the dispersing fine silt materials. Similarly, the persistent organic pollutants (dioxins and furans), adsorb preferentially to organic particles present amongst the silt/clay sediment fractions. Accordingly, any persistent organic pollutants created during the *KS Endeavor* conflagration would have been broadcast over an extensive area of the Bayelsa marine habitats and, potentially, have become incorporated into the sensitive coastal mangrove systems.

4.3 BENTHIC FAUNA

In the vicinity of the blowout crater, the sediment type deviated from that of the 'background,' silt-dominated, seabed substrate and comprised predominantly well-sorted

sands. As shown in the present survey report, this resulted in a marked modification of the benthic (seabed) fauna that could still be detected 4 years after the incident.

Throughout the near and far field survey areas there were 11 sampling sites at which no macrofaunal species were recorded. Nine of these grossly depauperate sites were located within the nearfield survey area. The sites in, and in the immediate vicinity of, the blowout crater displayed particularly depauperate macrofaunal assemblages with six sites yielding no macrofauna within the samples (Sites 38, 39, 46, 47, 54 and 62) and an additional four sites with just a single species being observed (Sites 40, 41, 51 and 56).

It was noted in the earlier Physalia report (Physalia, 2016a) that, throughout the near field sites, the macrofauna assemblages were generally depauperate/impoverished. However, at the time of writing, it had not been possible to determine whether this was as a consequence of the *KS Endeavor* blowout incident or whether they were representative of background coastal benthic (seabed) conditions within the Bayelsa area. The subsequent (present) analyses of the far field macrofaunal samples demonstrated that the near field sites supported lower abundances and less species-rich macroinvertebrate assemblages than those described at sites located further afield. The mean densities and mean species richness values of the near field macrofaunal assemblages were *statistically significantly lower than those from the far field survey area*. This indicated that the macrofaunal communities of the nearfield sites had not recovered fully from the impacts of the *KS Endeavor* blowout incident.

The meiofaunal bioindicator nematode communities also revealed evidence of persistent, adverse environmental conditions (Section 3.5.1). These diverse and abundant species are generally held to be the most species-rich and diverse invertebrate group present in aquatic habitats (Trett *et al.*, 2009). These include species that are the last to survive in the most grossly contaminated conditions. Samples collected from three sites located within the central section of the survey area (Sites 50, 51 and 54) yielded 3 or less species per sample. In the case of Site 51, one species only was identified and accounted for 9 nematode specimens per litre sediment (*Terschellingia longicaudata*). This contrasts with the peak density of over 14,800 nematodes per litre of sediment at Site 53 (located at the eastern edge of the near-field grid) and 42 species recorded at Site 16 located in the far field area to the west of the former *KS Endeavor* well head site. The persistence of such species poor meiofaunal nematode assemblages four years after an event is very unusual. Benthic nematode communities respond rapidly to changing condition and it would be expected that the assemblages at these sites would have recovered to a 'background' community structure or, if habitat conditions were modified but stable, to an alternative community structure comprising species compatible to the new conditions (see Forster, 1998). However, at Sites 50, 51 and 54, this had not occurred and indicate the influence of on-going, or sporadic disturbance events. Given the information currently available, it is not possible to determine whether this disturbance is (i) physical disturbance of the habitat (sediment), (ii) chemical contaminants or (iii) both.

The modification of the benthic habitat in the vicinity of the *KS Endeavor* blowout site is described in Section 3.2 and outlined in Section 4.1, above. These sediments comprised primarily sand fractions with markedly reduced silt/clay fractions. The multivariate, 'pattern-seeking' analyses undertaken by Physalia on the meiofaunal nematode communities

demonstrated that the assemblages associated with these modified sediment deviated markedly from the communities supported by the silt/mud habitats located further afield. In the case of the nematodes and the meiofaunal copepods, species that did not, and presumably could not have, occurred in the background silt/mud conditions had colonised these coarser, modified substrata. Consequently, any modification of the sediment 'granulometry' (sediment type and the relative proportions of sand and silts) caused by the redistribution of material resulting from the *KS Endeavor* incident should be considered an ecological impact.

4.4 EVIDENCE OF ON-GOING CRATER DISTURBANCE

As discussed in Section 4.1 above, during the field survey, thin layers of sand were observed overlying fine, silt-dominated sediments at six sites in the proximity of the former *KS Endeavor* well head (see Plate 4; Appendix G). These observations verified by the Chevron representative accompanying the Verde survey team. Had these sands been deposited during the initial *KS Endeavor* blowout and conflagration, four years prior to the field survey, they would have been covered by alluvial silts during the intervening period and incorporated into the muddy sediment. The observation of these sand layers on top of the muddy substrata indicates a more recent deposition of coarser grained particulate materials. As stated in Section 4.1 above, the only rational source of sands located in this region is the *KS Endeavor* blowout crater itself. The observation of surficial sand layers in the vicinity of the *KS Endeavor* site is indicative of on-going, sporadic displacement of materials from the blowout crater. Such displacement of material, including the relatively dense sand fractions, would have occurred only if there had been significant quantities of gas emitted through the substrata within the crater at the former well head site.

The findings of the side scan sonar survey corroborate the suggestion that emission of gas from the blowout crater bed was continuing at the time of the 2016 survey. The side scan results demonstrated backscatter features that were consistent with on-going gas seepages (Irish Hydrodata, 2016).

There was also evidence from both the field sampling observations and the meiofaunal nematode community data to show that the benthic habitats in the vicinity of the *KS Endeavor* blowout incident were subject to persistent and on-going perturbations. As noted earlier in this section, the nematode communities within the crater sediment were extremely depauperate in terms of both species richness and total densities (abundance). Had these habitats been stable, undisturbed and not subject to either chemical or physical perturbation, the nematode communities would have recovered to species richness and diversities equivalent to those of the surrounding habitats. However, evidence from the survey described here demonstrates clearly that this had not occurred over the four years since the blowout incident. It can be deduced, therefore, that the crater habitats were subject to persistent and/or sporadic disturbance.

5 REFERENCES

This report to be cited as:

Physalia (2016b). *The KS Endeavor Blowout Incident: Residual Marine Benthic Impact Assessment. Draft Supplementary Report; Near and Far Field Survey Areas.* A survey report prepared for Rufus-Isaacs, Acland and Grantham LLP, California, by Physalia Limited Consultant & Forensic Ecologists/Applied Sciences

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Bayelsa State Government (2012). Environmental Post Impact Assessment of Chevron Rig Gas Blowout, May 2012. pp 119

Environmental Accord (2015). KSE Post Impact Assessment (PIA) Environmental Monitoring (Field Report). Report prepared by Environmental Accord Nigeria Limited for Chevron Nigeria Limited.

Forster, S.J. (1998). *Aspects of the Ecology of Free-living Nematode Assemblages in a Temperate Intertidal Mudflat.* Queen Mary and Westfield College, University of London. 312 pp.

Fugro (2014). Report of *KS Endeavor* post impact assessment for Chevron Nigeria Limited. Report no.: S-1204C. Final Report. Fugro Nigeria Ltd.

Herut, B. and Sandler, A. (2006). Normalisation methods for pollutants in marine sediments: review and recommendations for the Mediterranean. *Israel Oceanographic and Limnological Research*. IOLR Report H18/2006, Submitted to UNEP/MAP; Pages 1 -23.

Ho, H.H., Swennen, R., Cappuyns V., Vassilieva E., Tran, T.V. (2012). Necessity of normalization to aluminum to assess the contamination by heavy metals and arsenic in sediments near Haiphong Harbor, Vietnam. *Journal of Asian Earth Sciences* **56:** 229–239

Lambshead, P.J.D. (1986). Sub-catastrophic sewage and industrial waste contamination as revealed by nematode faunal analysis. Marine Ecological Progress Series, **29**: 247-260

Mahu, E., Nyarko, e., Hulme, S., Swarzenski, P., Asiedu, D.K. and Coale, K.H. (2016). Geochronology and historical deposition of trace metals in three tropical estuaries in the Gulf of Guinea. *Estuarine, Coastal and Shelf Science* **177:** 31-40

Physalia (2016a). *The KS Endeavor Incident; Residual Marine Benthic Impact Assessment.* A survey report prepared for Rufus-Isaacs, Acland and Grantham LLP, California, by Physalia Limited Consultant & Forensic Ecologists/Applied Sciences

Schropp, S.J., Lewis, F.G., Windom, H., and Burney, L.C. (1990). Interpretation of metal concentrations in estuarine sediments of Florida using aluminum as a reference element. *Estuaries and Coasts*, **13**(3): 227-235

SIA Resources (2012). Post impact assessment of Chevron (*K.S. Endeavor* (Panama)) rig wellhead gas explosion on the environmental qualities, socio-economic and health of

Koluama communities (clan) Southern Ijaw local government area, Bayelsa State. Draft Final Report, pp. 104

Summers, J.K., Wade, T.L., Engle, V.D., and Malaeb, Z.A. (1996). Normalization of Metal Concentrations in Estuarine Sediments from the Gulf of Mexico. *Estuaries*, **19**, No. 3: pp. 581-594.

Trett, M.W. (1984). *The Cephalic Sense Organs of Nematodes*. Volumes 1 and 2. Under the supervision of Professor Donald L. Lee, University of Leeds. 215 pp. plus 111 plates.

Trett, M.W., Moss, R., Calvo Urbano, B. and Wilkinson, G. (2012). Carbon Disulphide - Contaminant or Biogenic Compound? A New Perspective. In *Environmental Forensics 201*1: 232-243. Editors Morrison, R.D. and O'Sullivan, G. *Royal Society of Chemistry*, Cambridge.

Trett, M.W., Calvo Urbano, B., Forster, S.J. and Trett, S.P. (2009). Chapter 12; Commercial aspects of the use of meiofaunal nematodes as bioindicators. In *Nematodes as Environmental Bioindicators*. Eds., Wilson, M.J. and Kakouli-Douarte, T., CAB International; Wallingford and Cambridge.

Trett, M.W., Calvo Urbano, B., Forster, S.J., Hutchinson, J.D., Feil, R.L., Trett, S.P. and Best, J.G. (2000). Terrestrial meiofauna and contaminated land assessment. *Environmental Science and Technology*, 34: 1594-1602

Trett, M.W. and Thurgood, R. (2008). Assessment and monitoring of actual ecological effects; nematodes in the service of industry and regulators. In P*roceedings of the 10th. International UFZ-Deltares-TNO Conference* on Soil-Water Systems (CONSOIL 2008). Milan, June 2008.1594-1602.

Irish Hydrodata (2016). *Appraisal report on marine survey data for Funiwa crater, Nigeria*. A bathymetric survey report prepared for Verde Environmental Group, by Walsh, J. Irish Hydrodata, Ballygarvan, Ireland

Addink, R. and Olie, K. (1995). Mechanisms of formation and destruction of polychlorinated dibenzo-p-dioxins and dibenzofurans in heterogeneous systems. *Environmental Science and Technology*, **29** (6): 1425-1435

Kuzuhara, S., Sato, H., Kasai, E., Nakamura, T. (2003). Influence of Metallic Chlorides on the Formation of PCDD/Fs during Low-Temperature Oxidation of Carbon. *Environmental Science and Technology* **37**(11): 2431-2435

Zhang, M., Yang, J., Buekens, A., Olie, K., Li, X. (2016). PCDD/F catalysis by metal chlorides and oxides. *Journal of Environmental Management* **157:** 111-117

Weber W.J. jr, VoiceT.C., Pirbazarit, M., Hunt, G.E. and Ulanoff, D.M. (1983). Sorption of hydrophobic compounds by sediments, soils and suspended solids ii - Sorbent evaluation studies. *Water Resources* 17 (10), 1443-1452

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Appendix A

Identiÿcation Codes and Taxonomic Lists of the Bioindicator Invertebrate Species

Physalia

Table A1. Taxonomic list of macrofaunal bioindicator invertebrate species recorded by Physalia in the January 2016 *KS Endeavor* survey area benthic habitats. Numbers shown represent identifier codes unique to each species/taxon in the survey area and relate to specimens and descriptions held by Physalia. These codes are used in the multivariate (mathematical) analyses of the communities and appear in the site-by-site results tables (see Table B1; Appendix B).

Phylum Sarcomastigophora; Subphylum Sarcodina; Class Granuloreticulosea

Order Foraminifera ("Foraminiferida")

Family Elphidiidae
48 *Elphidium* species

Family Miliolidae
57 *Quinqueloculina* species

Family Discorbidae
80 *Discorbis* species cf. *D. patelliformis*

Order Globigerinida;

Superfamily Globigerinacea
72 *Globigerina* species
100 *Streptochilus* species
? = *Laterostomella* sp.

Phylum Porifera

67 Fibrous poriferan species A indet.
82 Poriferan species species B indet.

Phylum Nemertea

Class Anopla; Subclass Heteronemertea

Family indet.
13 Species indet. (? Family Lineidae)
68 Nemertean species 1
77 ? *Micrura* species
84 Nemertean species 2

Phylum Annelida

Class Polychaeta
Order Phyllodocida

Family Goniadidae
24 *Goniada maculata*

Family Nepthyidae
11 *Nephthys sphaerocirrata*

Family Pilargidae
17 *Sigambra* species

Family Syllidae
26 *Syllis* species

Order Amphinomida

Family Amphinomidae
12 Amphinomid species

Order Eunicida

Family Onuphidae
1 *Diapatra neapolitana*
6 *Onuphid* species

Order Orbiniida

Family Orbiniidae
33 *Scoloplos armiger*

Order Spionida

Family Spionidae
15 *Prionospio* species 1
19 *Prionospio* species 2
21 *Prionospio pinnata*
30 Spionid species
25 *Scolelepis squamata*

Order Magelonida

Family Magelonidae
16 *Magelona* species

… continued

Order Cirratulida

Family Chaetopteridae
22 *Spiochaetopterus vitrarius*

Family Cirratulidae
3 *Cirratulus* species
10 *Tharyx dorsobranchialis*
7 Cirratulid species 1
23 Cirratulid species 2
39 Cirratulid species 3

Family Paraonidae
20 *Aricidea capensis*
9 *Paraonis gracilis oculata*

Family Pectinariidae
2 Pectinariid species

Family Cossuridae
14 *Cossura longocirrata*

Order Capitellida

Family Capitellidae
5 Capitellid species
4 *Mediomastus* species
8 *Notomastus* species

Family Maldanidae
35 Maldanid species

Order Terebellida

Family Terebellidae
23 Terebellid species indet.

Family Ampharetidae
27 Ampharetid species 1
28 Ampharetid species 2

Order Sabellida

Family Sabellidae
18 Sabellid species

Annelid taxa - family not determined
31 NG.16.A
32 NG.16.B

Phylum Biramia

Class Copepoda

Superorder Gymnoplea;
Order Calanoida

Sub-family Calanoidea

Family Calanidae
29 Calanid species
cf. *Centropages* species
(possibly *C. brachiatus*)
45 *Calanus* species
(cf. *C. finmarchicus*)
81 Calanoid species 1

Class Malacostraca; Order Mysida

Family Mysidae; Sf. Rhophthalminae
49 cf. *Rhopalophthalmus* species

Sub-class Eumalacostraca

Order Euphausiacea;
Suborder Pleocyemata

Family Euphausiidae
42 *Euphausia* species
cf. *E. lucens*

Order Decapoda;
Suborder Pleocyemata

Superfamily Alphaeoidea
Family Alphaeidae
41 *Alphaeus* species
cf. *A. crassimanus*

Infraorder Anomura;
Superfamily Paguroidea;
Family Paguridae
53 *Pagurus* species
cf. *P. mbizi*
102 *Anapagurus* species

Infraorder Brachyura;
Family Grapsidae;
95 *Pachygrapsus* species(?)

Infraorder Axiidea;
Family Callianassidae
51 *Callianasa turnerana*

Order Amphipoda

Family Liljeborgiidae
40 Liljeborgiid species indet.

Family Ampeliscidae
43 *Ampelisca* species 1
54 *Ampelisca* species 2 (cf. *A. brevicornis*)
89 *Ampelisca* species 3 (red eye)

Order Cumacea

Family Bodotriidae
47 *Iphinöe* species ? *Iphinöe senegalensis*

Subfamily Vaunthompsoniinae
44 ? *Cumopsis* species

Family indet.
85 Damaged cumacean Species unidentified

Phylum Mollusca

Class Aplacophora;
Order Chaetodermatida
Family Prochaetodermatidae
86 *Prochaetoderma* sp. ?*P.yongei*

Class Bivalvia;
Sub-class Metabranchia

Order Veneroida; Superfamily Tellinoidea

Family indet.
96 Bivalve Juveniles cf. Tellinoidea species

Family Tellinidae
36 Tellinid species (?*Tellina*)

Family Cardiidae
65 Cardiidae species indet.
66 *Cardium* juv. (cf. *C. costatum*)

Sub-class Heterodonta;
Superorder Anomalodesmata;
Family Cuspidariidae
71 *Cuspidaria abbreviate*

Order Adepedonta;
Superfamily Solenoidea;
Family Pharidae
94 *Sinupharus combieri*

Sub-class Protobranchia;
Order Nuculanida

Family Nuculanidae
75 *Nuculana* species

Sub-class Pteriomorpha;
Order Arcida

Family Arcidae
83 Arcid species indet.

Order Pectinida

Family Spondylidae
88 *Spondylus* species indet. Juvenile

Class Gastropoda;
Sub-class Orthogastropoda
Superorder Caenogastropoda;
Order Sorbeoconcha;
Sub-order Hypsogastropoda

Family Fasciolariidae;
Subfamily Fusininae
38 *Fusinus* species 1
98 *Fusinus* species juvenile

Sub-class Heterobranchia

Superfamily Pyramidelloidea;
Family Pyramidellidae
52 Pyramidaelloidea species 2
58 Pyramidellidae species 1
59 *Ondina* species (cf. *O. dilucida*)
64 Pyramidellidae species 2
63 Pyramidellidae species 3
92 *Chrysallida* species (possibly *C. interstincta*)
97 *Chrysallida* species (not *C. interstincta*)
74 *Eulimella* species (cf. *E.flagellum*)

Family Pyramidellidae;
Subfamily Odostomiinae
55 Odostomiinae species 1
56 Odostomiinae species 2
76 *Odostomina conoidea*
87 *Megastoma* species cf. *M. conoidea*

Order Sorbeoconcha;
Sub-order Hypsogastropoda

Family Muricidae
46 Muricidae species indet.

Infraclass Opishthobranchia;
Order Cephalaspidea;
Superfamily Bulloidea

Family Retusidae
61 *Retusa* species 1
73 *Retusa* species 2 (Damaged)

Sub-class Heterobranchia; Infra-Class Opisthibranchia;
Order Nudibranchia
70 *Cavolinia* species

Class Scaphopoda; Order Dentaliida;
Family Dentaliidae
60 *Dentalium* species
93 *Antalis* species cf. *A. dentalis*

Gastropoda Species indet.
34 *?Fusinus* juveniles indet.

Superfamily Naticoidea
99 Naticoid species indet.

Phylum Chaetognatha

Class Sagittoidea; Order Aphragmophora;
Family Sagittidae

78 *Sagitta* species cf. *S. setosa*

Phylum Echinodermata

Class Holothuroidea
Holothurian indet.
90 *?Leptotentacta* species

Phylum Sipunculida

Class Phascolosomatidea;
Order Phascolosomatida;
Family Phascosomatidae
101 *Phascolosoma* species
Probably *P. granulatum*

Table A2. Table presenting the full taxonomic list of the meiofaunal Nematoda recorded by the taxonomic team at Physalia in the samples collected during the January 2016 *KS Endeavor* residual impact assessment survey. The numbers shown beside each species are unique identifier codes (UICs) ascribed to each taxa in each survey region worldwide. These relate to specimens in the faunal reference collections and/or descriptions catalogues maintained at Physalia. The UICs are essential for the multivariate (mathematical) analyses of the communities and appear in the site-by-site results tables (see Table B2; Appendix B).

Phylum Nematoda

Class Enoplea; Sub-class Enoplia

Order Enoplida; Sub-order Enoplina

Family Thoracostomopsidae

64 *Enoploides* species
59 *Enoplolaimus* species
87 *Polygastrophora* species

Sub-order Trefusiina

Family Trefusiidae

60 *Rhabdocoma* species

Sub-order Oncholaimina

Family Enchelidiidae

112 *Eurystomina* species 1 (? *E. caesiterides*)
140 *Eurystomina* species 2

Family Oncholaimidae

58 *Oncholaimus* species
83 *Viscosia* species (? *V. elegans*)
126 Oncholaimidae species

Sub-order Ironina

Family Oxystominidae

2 *Halalaimus* species 1
72 *Halalaimus* species 2 (? *H. isaitshikovi*)
94 *Halalaimus* species 3
95 *Halalaimus* species 4
111 *Halalaimus* species 5
114 *Halalaimus* species 6
116 *Halalaimus* species 7
85 *Nemanema* species
3 *Oxystomina* species 1 (? *O. asetosa*)
71 *Oxystomina* species 2 (? *O. elongata*)
107 *Oxystomina* species 3
1 *Thalassolaimus* species 1
46 *Thalassolaimus* species 2
4 Oxystominidae species

Sub-order Tripyloidina

Family Tripyloididae

65 *Bathylaimus* species

Class Chromadorea

Sub-class Chromadoria

Order Chromadorida

Sub-order Chromadorina

Family Chromadoridae

73 *Chromadora* species
125 *Chromadorita* species
66 *Neochromadora* species 1
124 *Neochromadora* species 2
150 *Neochromadora* species 3
6 Chromadoridae species 1 (? *Actinonema)*
153 Chromadoridae species 2

Family Cyatholaimidae

103 *Marylynnia* species (? *M. complexa*)
62 *Paracanthochus* species 2
55 *Paracanthonchus* species 1 (? *P. longus*)
57 *Paracyatholaimus* species (? *P. multispiralis*)

115 *Paralongicyatholaimus* species
7 *Pomponema* species

Family Ethmolaimidae
15 *Comesa* species 1 (? *C. cuanensis*)
16 *Comesa* species 2 (? *C. vatadinii*)
17 *Filitonchus* species
20 *Neotonchus* species
19 Ethmolaimidae species 1
149 Ethmolaimidae species 3
151 Ethmolaimidae species 4
157 Ethmolaimidae species 5

Family Neotonchidae
88 Ethmolaimidae species 2 (? *Ethmolaimus)*

Family Selachinematidae
93 *Cheironchus* species
28 *Choniolaimus* species (? *C. papillatus*)
51 *Richtersia* species 1 (? *R. pilosa*)
119 *Richtersia* species 2
77 *Synonchiella* species (? *S. reimanni*)
144 Selechinomatidae species

Order Desmodorida; Sub-order Desmodorina

Family Desmodoridae
8 *Chromaspirina* species
80 *Leptonemella* species

Family Microlaimidae
142 *Calomicrolaimus* species
146 *Microlaimus* species 1 (? *M. acinaces*)
152 *Microlaimus* species 2 (? *M. globiceps*)
162 Microlaimidae species

Order Desmoscolecida

Family Desmoscolecidae
13 *Quadricoma* species
14 *Quadricoma* species
50 *Quadricoma* species
105 *Quadricoma* species

Order Monhysterida; Sub-order Monhysterina

Family Monhysteridae
52 *Geomonhystera* species (? *G. filicaudata*)
92 *Monhystera* species 1
159 *Monhystera* species 2

Family Sphaerolaimidae
40 *Sphaerolaimus* species 1
41 *Sphaerolaimus* species 2
75 *Sphaerolaimus* species 3

Family Xyalidae
76 *Daptonema oxycerca*
42 *Daptonema* species 1
97 *Daptonema* species 2
118 *Daptonema* species 4
143 *Daptonema* species 5
133 *Gnomoxyala* species
63 *Gonionchus* species 1
122 *Gonionchus* species 2
43 *Metadesmolaimus* species 1
131 *Metadesmolaimus* species 2
132 *Paramonhystera* species
120 *Pseudosteineria* species
56 *Rhynchonema* species
145 *Theristus* species
96 *Trichotheristus* species
61 *Xyala* species 1
141 *Xyala* species 2
44 Xyalidae species 1
74 Xyalidae species 2
139 Xyalidae species 3

Sub-order Linhomoeina

Family Linhomoeidae
32 *Eleutherolaimus* species (? *E. stenosoma*)
33 *Linhomoeus* species
163 *Linhomoeus* species 1
34 *Metalinhomoeus* species 2
35 *Terchellingia longicaudata*
36 *Terchellingia* species 1
37 *Terchellingia* species 2
38 *Terchellingia* species 3
39 *Terchellingia* species 4
135 *Terchellingia* species 5
53 Linhomoeidae species 1

110 Linhomoeidae species 2
117 Linhomoeidae species 3
138 Linhomoeidae species 4
158 Linhomoeidae species 5

Order Araeolaimida

Family Axonolaimidae

78 *Axonolaimus* species
70 *Odontophora* species 1
109 *Odontophora* species 2
31 *Parodontophora* species

Family Bodonematidae

106 *Bodonema* species

Family Comesomatidae

102 *Dorylaimopsis* species
9 *Laimella* species
130 *Paracomesoma* species
10 *Sabatieria* species 1
11 *Sabatieria* species 2
12 *Vastostoma* species 1
137 *Vastostoma* species 2

Family Diplopeltidae

29 *Campylaimus* speices 1
47 *Campylaimus* speices 2
91 *Diplopeltula* speices 1
101 *Diplopeltula* speices 2

Order Plectida

Family Aegialoalaimidae

5 *Aegialoalaimus* species 1
48 *Cyartonema* species
84 *Diplopeltoides* species
104 Aegialoalaimid species
(? *Cyartonema)*

Family Ceramonematidae

54 *Ceramonema* species 1
67 *Ceramonema* species 2
89 *Ceramonema* species 3
90 *Ceramonema* species 4
69 *Dasynemoides* species 1
121 *Dasynemoides* species 2
134 *Metadasynemella* species
68 *Metadasynemoides* species 1
113 *Metadasynemoides* species 2
81 *Pselionema* species 1
155 *Pterygonema* species 1
161 *Pterygonema* species 2

Family Leptolaimidae

127 *Antomicron* species
86 *Camacolaimus* species 1
(? *C. tardus*)
21 *Camacolaimus* species 2
156 *Camacolaimus* species 3
(? *C. longicauda*)
23 *Leptolaimus* species 1
(? *L. limicolus*)
24 *Leptolaimus* species 2
25 *Leptolaimus* species 3
26 *Leptolaimus* species 4
98 *Leptolaimus* species 6
22 *Leptonemoides* species 1
79 *Leptonemoides* species 2
136 *Leptonemoides* species 3
148 *Leptonemoides* species 4
27 Leptolaimidae species 1
(? *Procamacolaimus)*
99 Leptolaimidae species 2
154 Leptolaimidae species 3
160 Leptolaimidae species 4

Family Tarvaiidae

30 *Tarvaia* species

Class Indet.; Sub-class Indet.
Order Indet.

Family Indet.

45 KSE16.A
49 KSE16.B
108 KSE16.C
123 KSE16.D
128 KSE16.E
147 KSE16.F

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Appendix B

Community Data Tables for the Faunal Assemblages; Species and their Abundances

Physalia

Table B1. Site-by-site results table for macrofaunal communities sampled in the January 2016 *KS Endeavor* residual impact assessment survey. Species codes (in brackets) are followed by the numbers of animals belonging to that species/taxa recorded per litre sediment. The key to the species codes used is given in Table A1 in Appendix A.

Site	Identification Code and Number per Litre Sediment	Species	Densities
1	None Observed	0	0
2	(1)1; (7)1; (48)1; (49)1; (51)1; (52)1	6	6
3	(2)2	1	2
4	None Observed	0	0
5	(1)1; (2)8; (4)1; (5)1; (7)4; (11)2; (13)2; (16)1; (17)1; (18)1; (19)1; (34)1; (53)3; (54)2	14	29
6	(2)1; (11)1; (55)1; (56)1; (57)1	5	5
7	(2)1; (5)1; (8)1; (20)1; (45)1; (58)1; (59)1	7	7
8	(2)1; (11)1; (57)2; (58)1; (60)2; (61)1; (62)1; (103)1	8	10
9	(1)1; (8)1; (45)1; (54)2; (55)2; (63)2; (104)1	7	10
10	(2)6; (7)4; (8)1; (36)1; (57)1; (64)5; (65)1; (66)1	8	20
11	(8)1; (45)3; (63)1; (67)1; (68)2	5	8
12	(4)1; (11)1; (20)1; (25)2; (33)1; (35)1; (45)1; (69)1; (70)3; (71)1	10	13
13	(45)2; (62)1; (72)1; (73)1; (74)1; (75)1	6	7
14	(2)2; (3)1; (8)2; (17)1; (20)1; (63)1; (64)3; (76)1	8	12
15	(8)6; (16)1; (21)2; (35)11; (45)1; (47)2; (63)1; (77)1; (78)1; (106)1	10	27
16	(2)3; (3)1; (5)1; (7)1; (8)1; (11)4; (16)2; (20)3; (25)1; (45)2; (53)1; (70)1; (71)1; (79)1; (80)1; (105)1	16	25
17	(2)2; (3)3; (11)1; (14)1; (16)1; (25)1; (33)1; (45)1; (48)2; (58)1; (72)1; (81)1; (82)1	13	17
18	(1)10; (2)1; (4)4; (7)2; (8)2; (11)1; (14)1; (16)2; (21)2; (27)1; (35)4; (36)1; (51)1; (63)1; (64)1; (66)1; (68)2; (78)1; (83)1; (84)1; (85)1; (86)1	22	42
19	(2)1; (3)1; (8)2; (21)1	4	5
20	(2)1; (3)1; (4)2; (56)2; (64)2; (87)1; (88)1; (89)1; (90)1; (91)1; (102)21	11	34
21	(1)3; (2)4; (4)1; (8)1; (16)1; (17)1; (35)1; (64)1	8	13
22	(2)2; (3)1; (8)3; (29)2; (45)1; (57)1; (58)1; (64)2; (92)1	9	14
23	(3)3; (16)2; (25)1; (35)2; (51)2; (70)1; (71)2; (91)2; (93)1	9	16
24	(3)3; (15)2; (94)1	3	6
25	(51)1; (57)1; (58)1; (64)1; (72)2; (74)1; (83)1; (87)1; (95)2; (96)2; (97)1; (98)1; (99)1; (100)1	14	17
26	(1)3; (2)4; (16)1; (17)1; (25)1; (45)2; (101)1	7	13
27	None Observed	0	0
28	(36)1	1	1
29	(11)1	1	1
30	(1)1; (2)5; (8)1; (9)1	4	8
31	(1)1; (2)4; (3)1; (4)1	4	7
32	(5)1; (13)1	2	2
33	(7)1	1	1
34	(2)1; (11)1; (13)1; (15)1	4	4

Site	Identification Code and Number per Litre Sediment	Species	Densities
35	(14)2; (21)1; (36)1; (46)1	4	5
36	(13)1	1	1
37	None Observed	0	0
38	None Observed	0	0
39	None Observed	0	0
40	(47)4	1	4
41	(1)1	1	1
42	(1)1; (2)1; (4)3; (5)1; (6)1; (7)2; (11)1; (26)1; (27)2; (28)1	10	14
43	(7)1; (9)1; (11)1	3	3
44	(1)7; (11)1; (12)1; (14)1; (24)1	5	11
45	(16)1; (25)1	2	2
46	None Observed	0	0
47	None Observed	0	0
48	(1)1; (7)1; (29)1; (41)2	4	5
49	(2)1; (4)1; (5)2; (8)1; (10)1	5	6
50	(2)1; (4)1; (5)1; (6)1; (7)2; (43)1	6	7
51	(2)7	1	7
52	(1)1; (4)4; (7)1; (11)1; (16)2	5	9
53	(1)2; (2)5; (4)3; (7)1; (8)1; (11)1; (13)1; (22)1	8	15
54	None Observed	0	0
55	(1)1; (2)7; (4)2; (7)2; (8)2; (11)4; (23)1; (39)1; (43)2; (44)1	10	23
56	(16)1	1	1
57	(11)1; (30)1; (42)1	3	3
58	(1)1; (2)4; (4)8; (8)1; (11)1; (13)1; (16)1	7	17
59	(1)1; (2)2; (8)1; (11)1; (12)1; (13)1	6	7
60	(2)1; (4)1; (17)1	3	3
61	(2)1; (5)1; (7)1; (8)3; (11)2; (14)2; (16)1; (29)1; (31)1	9	13
62	None Observed	0	0
63	(2)2; (7)1; (8)2	3	5
64	(1)2; (2)1; (4)1; (16)1; (17)3	5	8
65	(1)1	1	1
66	(2)5; (16)2; (34)2; (37)1; (38)1	5	11
67	(1)1; (2)1; (11)2; (39)1	4	5
68	(1)2; (2)3; (8)1; (11)2; (15)1; (32)1; (39)1; (40)2	8	13
69	(7)1; (42)1; (45)1	3	3
70	None Observed	0	0
71	(1)5; (2)1; (4)1; (8)1; (17)1; (35)1	6	10
72	(2)4; (8)1; (11)1; (16)1; (34)1	5	8
73	(1)2; (2)3; (4)2; (8)2; (11)1; (20)2; (33)2	7	14
74	(2)1; (8)1	2	2

Table B2. Site-by-site results table for the meiofaunal nematode communities present in the *KS Endeavor* survey area, January/February 2016. Species codes (in brackets) are followed by the numbers of animals belonging to that species recorded per litre sediment. The key to the species codes used is given in Table A2 (Appendix A).

Site	Identification Code and Number per Litre Sediment	Number of Species	Number of Animals	Feeding Type Ratio
S 1	(3)36; (8)36; (10)36; (12)36; (15)725; (17)73; (19)73; (20)145; (23)36; (29)36; (31)73; (32)181; (35)109; (36)653; (37)580; (38)109; (40)73; (42)145; (43)254; (53)36; (70)36; (74)36; (77)36; (115)36; (128)36	25	3625	0.63
S 2	(6)49; (7)588; (9)16; (12)33; (21)16; (23)212; (29)147; (35)16; (36)82; (47)49; (51)33; (52)33; (71)33; (114)49; (120)49; (123)16; (126)82; (146)33; (154)16; (155)65; (156)16	21	1633	0.14
S 3	(4)22; (9)22; (11)290; (12)45; (15)112; (19)67; (29)45; (31)22; (32)22; (34)67; (35)246; (37)201; (38)22; (43)67; (53)22; (77)112; (80)45; (86)22; (115)201; (128)22; (130)67; (137)402; (138)22; (139)67	24	2232	1.47
S 4	(3)100; (4)50; (6)216; (7)382; (8)33; (12)50; (15)17; (23)17; (42)299; (43)249; (47)17; (51)17; (52)33; (76)50; (80)33; (86)17; (118)17; (120)17; (130)33; (131)17	20	1664	1.00
S 5	(12)17; (15)17; (20)8; (23)102; (30)17; (32)8; (36)415; (37)34; (40)34; (42)8; (43)127; (44)8; (45)42; (128)8	14	845	6.00
S 6	(12)20; (15)139; (17)100; (19)20; (29)40; (31)20; (32)80; (34)60; (35)60; (36)219; (37)618; (38)219; (43)40; (49)60; (53)139; (74)80; (77)60; (163)20	18	1994	1.62
S 7	(7)8; (8)16; (11)24; (12)8; (15)24; (19)8; (20)8; (23)73; (29)8; (31)16; (32)24; (35)24; (36)154; (37)49; (40)8; (42)49; (43)81	17	582	2.88
S 8	(4)25; (6)101; (7)202; (8)126; (10)101; (11)25; (12)480; (15)51; (23)25; (29)76; (30)25; (33)25; (35)76; (36)76; (37)126; (43)51; (50)51; (51)25; (53)101; (76)25; (77)253; (80)76; (81)126; (83)51; (93)25; (103)25; (115)76; (123)101; (148)25; (159)25	30	2576	0.61

Site	Identification Code and Number per Litre Sediment	Number of Species	Number of Animals	Feeding Type Ratio
S 9	(3)48; (4)48; (6)96; (7)48; (8)864; (10)336; (15)336; (20)48; (23)96; (29)288; (31)240; (32)48; (35)96; (36)240; (37)432; (38)144; (42)144; (43)96; (45)48; (49)144; (50)48; (51)48; (72)192; (74)48; (78)144; (80)48; (84)48; (93)48; (94)96; (103)192; (108)48; (128)192	32	4992	0.55
S 10	(3)13; (8)13; (10)245; (12)26; (15)77; (17)26; (21)13; (29)142; (30)13; (31)26; (34)26; (35)90; (36)270; (37)180; (38)39; (40)51; (43)13; (49)13; (71)13; (153)13	20	1302	4.40
S 11	(23)48; (32)10; (35)10; (40)38; (44)38; (56)10; (124)10; (140)10; (141)10; (142)10	10	194	3.50
S 12	(1)46; (2)92; (6)92; (7)462; (8)92; (10)138; (11)462; (12)231; (20)46; (25)46; (29)92; (31)369; (38)138; (42)138; (44)46; (49)92; (75)138; (76)231; (77)369; (81)46; (105)46; (115)46; (137)831; (139)92; (148)46; (149)46; (150)46; (151)46; (152)46	29	4611	1.20
S 13	(1)19; (12)48; (15)38; (19)48; (20)10; (21)10; (23)29; (29)19; (30)10; (32)10; (34)38; (35)86; (37)143; (38)10; (53)10; (72)10; (74)10; (77)48; (78)19; (80)19; (115)10; (137)19	22	663	0.75
S 14	(15)171; (20)7; (35)14; (36)219; (37)48; (40)7; (43)7; (44)7	8	480	0.08
S 15	(3)40; (7)40; (10)20; (12)60; (15)700; (20)20; (23)100; (32)20; (36)520; (40)60; (42)40; (44)240; (72)20; (79)20; (128)60; (130)40	16	2000	0.42
S 16	(1)176; (4)88; (6)132; (7)264; (8)704; (10)220; (12)132; (14)44; (15)88; (20)44; (23)132; (29)132; (30)88; (31)88; (34)44; (35)44; (36)176; (37)132; (39)44; (42)264; (44)44; (49)88; (50)44; (51)44; (53)88; (72)44; (75)132; (76)88; (77)44; (78)44; (80)88; (94)88; (102)44; (104)44; (115)88; (116)44; (128)44; (132)44; (133)44; (134)88; (135)44; (136)44	42	4400	0.67
S 17	(6)10; (7)31; (8)10; (10)31; (12)52; (15)72; (19)10; (20)21; (29)10; (30)10; (31)21; (32)10; (35)10; (37)62; (43)10; (44)10; (49)10; (53)10; (74)10; (75)21; (76)10; (80)21; (83)21; (101)10; (104)10; (117)10; (120)10; (157)10	28	533	0.73
S 18	(4)56; (7)56; (12)112; (15)758; (20)112; (25)28; (29)56; (30)112; (31)112; (32)84; (34)28; (35)56; (36)112; (37)421; (38)281; (42)28; (43)28; (49)140; (74)28; (77)56; (78)28; (114)56; (147)28; (148)28	24	2804	0.24

Site	Identification Code and Number per Litre Sediment	Number of Species	Number of Animals	Feeding Type Ratio
S 19	(5)12; (7)24; (8)47; (12)12; (15)634; (19)12; (20)47; (23)129; (32)47; (36)59; (42)12; (44)47; (45)59; (105)12; (132)12; (158)12	16	1177	0.17
S 21	(3)68; (7)136; (8)475; (10)68; (11)271; (12)407; (15)543; (16)68; (23)678; (25)204; (26)68; (29)339; (31)339; (35)204; (36)1221; (37)475; (42)136; (45)68; (72)339; (74)68; (81)68; (107)68; (128)136; (130)339	24	6786	0.44
S 22	(4)17; (8)17; (11)17; (14)17; (15)846; (17)50; (20)481; (35)17; (36)17; (37)33; (45)50; (49)17; (77)17; (80)17; (86)50	15	1663	0.01
S 23	(4)88; (5)44; (6)88; (11)177; (12)1149; (15)44; (23)44; (25)44; (29)353; (35)88; (36)133; (37)44; (38)44; (39)44; (49)44; (50)88; (75)44; (76)221; (77)265; (81)133; (84)44; (86)88; (93)44; (102)88; (103)177; (105)44; (115)88; (116)44; (123)44; (133)44; (136)44; (137)177; (143)44; (148)88; (156)44; (160)44; (161)44; (162)44	38	4413	0.29
S 24	(6)183; (7)366; (8)1282; (10)183; (11)61; (12)488; (14)61; (20)122; (23)122; (25)61; (27)61; (29)122; (30)305; (31)61; (32)61; (35)61; (36)305; (37)183; (38)122; (42)183; (49)244; (50)61; (71)61; (75)61; (76)183; (77)122; (81)183; (83)366; (93)61; (102)61; (115)183; (120)122; (127)61; (128)61; (130)61; (137)122; (148)61; (150)61	38	6528	0.36
S 25	(3)163; (5)81; (6)163; (7)326; (8)2037; (10)81; (12)81; (13)81; (14)81; (15)163; (20)81; (23)81; (25)326; (29)244; (30)244; (31)81; (34)81; (35)81; (36)163; (37)244; (39)244; (43)81; (49)81; (51)244; (73)81; (76)978; (77)326; (78)81; (84)163; (92)163; (103)81; (107)81; (110)163; (115)81; (116)81; (143)81; (144)81; (145)163; (146)81	39	8218	0.58
S 26	(12)10; (15)94; (19)42; (21)10; (29)10; (32)21; (35)21	7	208	0.14
S 27	(9)7; (16)7; (17)7; (23)107; (24)7; (29)7; (34)29; (35)7; (36)50; (37)150; (38)7; (40)7; (44)7; (45)14	14	413	1.33
S 28	(7)8; (8)17; (10)17; (12)17; (15)67; (23)34; (27)8; (29)25; (34)8; (35)8; (36)134; (37)268; (38)8; (43)8; (45)17; (106)8	16	652	0.36
S 29	(4)96; (6)48; (7)48; (8)24; (10)24; (11)24; (12)120; (15)72; (16)24; (17)24; (20)24; (22)24; (23)143; (25)48; (29)167; (31)48; (32)24; (35)24; (36)287; (37)454; (38)143; (42)96; (45)72; (49)24; (71)24; (72)72; (74)48; (78)120; (86)24; (94)24; (95)24	31	2418	1.17
S 30	(15)237; (17)16; (19)8; (31)8; (35)16; (37)8	6	293	0.00

Site	Identification Code and Number per Litre Sediment	Number of Species	Number of Animals	Feeding Type Ratio
S 31	(3)32; (10)65; (12)65; (15)226; (17)65; (20)48; (22)16; (23)32; (25)129; (29)290; (32)65; (36)210; (37)113; (47)16; (49)16; (71)16; (72)81; (74)16; (76)16; (77)32; (78)16; (85)16; (91)16; (98)16	24	1613	0.52
S 32	(9)8; (15)92; (17)25; (19)8; (36)8; (37)58; (44)17; (45)25	8	241	0.07
S 33	(6)132; (7)73; (8)44; (9)15; (10)44; (11)15; (12)44; (15)380; (20)117; (23)102; (25)15; (29)29; (31)29; (32)15; (36)146; (37)102; (40)15; (42)29; (45)44; (49)15; (72)29; (76)15; (101)15	23	1464	0.17
S 34	(4)44; (6)88; (7)176; (8)792; (10)44; (14)44; (15)1144; (20)264; (23)44; (25)88; (27)44; (29)264; (31)220; (32)88; (36)308; (37)44; (42)176; (43)44; (45)264; (50)44; (51)132; (72)44; (77)44; (84)44; (104)44; (105)44	26	4576	0.18
S 35	(2)123; (3)62; (5)62; (6)185; (7)493; (8)62; (10)62; (12)369; (13)123; (15)1601; (20)739; (21)62; (23)185; (25)185; (27)62; (28)62; (29)800; (31)62; (32)123; (36)123; (37)308; (39)62; (45)308	23	6223	0.06
S 36	(4)27; (5)27; (6)549; (7)274; (8)137; (10)55; (12)82; (14)27; (15)302; (17)55; (20)110; (23)137; (25)27; (27)27; (29)55; (32)27; (35)27; (36)82; (37)27; (42)27; (43)27; (49)110; (50)137; (51)247; (69)27; (74)55; (83)27; (98)27; (107)27	29	2765	0.31
S 37	(3)13; (15)67; (16)27; (17)80; (23)134; (27)13; (32)27; (35)13; (36)227; (37)601; (40)13; (42)13; (44)27; (45)27; (77)13; (78)13; (79)27; (93)13	18	1348	1.43
S 38	(6)10; (14)10; (15)864; (20)28; (32)19; (43)10; (44)10	7	951	0.03
S 39	(2)107; (6)2242; (24)107; (25)107; (42)107; (47)534; (57)107; (63)214; (68)107; (77)107; (80)107; (83)534; (103)1602; (116)107; (118)427; (119)534; (120)3096; (121)107; (122)107; (123)534	20	10894	1.14
S 40	(6)73; (7)441; (54)734; (55)73; (56)73; (57)3598; (61)147; (66)220; (67)73; (68)441; (88)1175; (89)73; (90)587	13	7708	0.03
S 41	(7)127; (8)127; (9)21; (10)21; (15)591; (20)84; (23)127; (25)42; (29)105; (30)21; (31)63; (36)63; (37)42; (38)42; (42)42; (43)190; (45)211; (58)21; (66)21; (76)63; (79)21; (80)21; (104)21; (115)21	24	2108	0.35

Site	Identification Code and Number per Litre Sediment	Number of Species	Number of Animals	Feeding Type Ratio
S 42	(1)52; (2)103; (3)155; (4)52; (7)103; (8)1392; (10)103; (11)52; (12)361; (15)206; (17)52; (20)52; (22)52; (23)309; (25)103; (26)52; (29)206; (30)52; (32)52; (33)52; (36)309; (37)1083; (38)52; (41)52; (42)52; (44)52	26	5161	0.20
S 43	(5)16; (6)31; (7)31; (8)31; (10)16; (12)31; (15)486; (20)157; (23)63; (28)16; (29)172; (31)78; (32)47; (34)16; (36)47; (37)141; (38)31; (44)16; (45)16; (46)16; (47)31; (48)16; (49)16; (50)31; (51)16	25	1568	0.13
S 44	(6)51; (32)205; (54)103; (56)1591; (57)308; (59)2413; (61)51; (63)51; (65)257; (112)103	10	5133	6.00
S 45	(32)92; (54)183; (55)1327; (56)229; (57)1006; (58)320; (59)229; (60)503; (61)92; (62)92; (63)92; (64)92; (65)274; (66)46	14	4577	0.31
S 46	(2)8; (4)8; (6)51; (7)8; (8)8; (10)8; (12)101; (15)236; (23)8; (25)8; (29)8; (31)17; (35)42; (36)59; (37)17; (42)17; (44)17; (45)59; (66)8; (72)8; (76)8; (80)8	22	712	0.11
S 47	(6)21; (15)21; (43)156; (59)10; (61)10; (79)10; (90)10; (92)10	8	248	4.00
S 48	(15)398; (20)25; (23)8; (36)8; (40)8; (42)34; (73)8	7	489	0.43
S 49	(12)15; (15)82; (17)22; (20)22; (23)7; (29)104; (30)7; (35)52; (36)67; (37)163; (38)30; (41)37; (43)89; (44)15; (45)30; (70)7	16	749	0.75
S 50	(8)8; (51)8	2	16	1.00
S 51	(35)9	1	9	N/A
S 52	(4)21; (7)43; (8)235; (10)21; (12)107; (15)363; (20)85; (23)256; (24)21; (25)21; (29)64; (30)107; (31)64; (35)64; (36)213; (37)192; (42)21; (43)149; (45)64; (50)21; (51)85; (77)21; (80)21; (117)21	24	2280	0.41
S 53	(4)146; (6)582; (8)3056; (9)146; (10)146; (12)291; (15)728; (20)291; (23)437; (25)728; (29)582; (31)146; (36)1746; (37)4220; (38)437; (45)146; (49)146; (51)146; (77)291; (86)291; (104)146	21	14848	0.09
S 54	(43)15; (80)8; (86)15	3	38	2.00
S 55	(1)28; (2)28; (3)28; (6)28; (7)85; (8)338; (10)197; (12)197; (15)197; (19)28; (22)56; (23)28; (25)85; (29)310; (31)85; (34)28; (35)56; (36)423; (37)366; (38)85; (42)28; (74)85; (79)28	23	2817	0.50
S 56	(6)472; (7)189; (21)94; (32)94; (54)566; (55)94; (56)849; (57)1226; (58)94; (59)566; (61)2075; (65)283; (68)755; (69)94; (90)566; (96)189; (97)1038; (98)94; (99)94	19	9432	2.18

Site	Identification Code and Number per Litre Sediment	Number of Species	Number of Animals	Feeding Type Ratio
S 57	(32)151; (54)251; (55)502; (56)502; (57)1055; (58)753; (60)552; (61)201; (62)50; (64)50; (65)653; (66)100; (67)100; (68)50; (69)50	15	5020	0.88
S 58	(4)16; (6)49; (10)33; (12)82; (15)98; (20)33; (23)147; (29)65; (35)65; (36)310; (37)473; (38)16; (40)16; (42)33; (44)16; (45)16; (54)16; (56)49; (61)16; (66)16; (79)16; (83)33; (112)16	23	1630	1.33
S 59	(2)117; (3)59; (4)29; (6)59; (7)88; (8)205; (9)29; (10)117; (12)176; (15)381; (17)29; (20)29; (22)29; (23)59; (29)176; (30)29; (32)59; (34)29; (36)586; (37)381; (38)29; (45)59; (72)29; (74)29; (77)29; (78)29; (79)29; (95)29; (108)29; (109)29; (110)29; (111)29	32	3044	0.41
S 60	(1)12; (4)25; (6)12; (8)12; (10)12; (12)37; (15)248; (17)37; (19)37; (20)37; (22)25; (23)12; (29)50; (31)50; (35)25; (36)248; (37)334; (38)25; (40)12; (43)12; (44)37; (45)12; (49)25; (53)25; (94)12	25	1373	0.13
S 61	(3)36; (4)36; (8)36; (10)108; (12)180; (15)468; (19)36; (20)72; (23)36; (25)36; (29)396; (30)36; (35)36; (36)432; (37)1224; (38)108; (40)72; (43)72; (44)72; (45)36; (74)36; (79)36	22	3600	0.21
S 62	(1)48; (3)48; (4)48; (5)48; (6)339; (7)242; (8)97; (10)242; (12)436; (15)242; (17)97; (22)48; (23)339; (29)485; (30)97; (31)48; (35)242; (36)436; (37)533; (38)291; (42)97; (43)48; (44)48; (72)48; (73)48; (74)48; (79)48; (104)48; (120)48; (127)97	30	4984	0.45
S 63	(7)19; (10)38; (12)134; (15)267; (17)38; (23)76; (29)57; (34)38; (35)76; (36)248; (37)496; (38)76; (42)95; (43)38; (45)19; (58)115; (74)57; (77)19; (78)38; (95)19	20	1963	0.94
S 64	(6)282; (8)31; (10)94; (12)31; (15)439; (20)31; (23)282; (25)63; (29)251; (30)31; (31)94; (34)31; (36)407; (37)627; (40)31; (42)63; (44)31; (45)31; (47)31; (49)31; (79)31; (83)31; (103)31; (124)31; (125)63; (126)31	26	3130	0.21
S 65	(1)53; (3)53; (4)212; (7)53; (8)265; (9)53; (10)212; (12)371; (15)265; (17)159; (20)106; (23)159; (29)265; (30)53; (31)53; (32)53; (34)53; (35)106; (36)159; (37)1220; (38)265; (45)53; (49)53; (50)53; (53)212; (72)53; (74)212; (77)159; (78)106; (81)53; (84)106; (102)53; (103)53	33	5354	0.94

Site	Identification Code and Number per Litre Sediment	Number of Species	Number of Animals	Feeding Type Ratio
S 66	(1)51; (2)51; (3)101; (8)1319; (10)152; (12)152; (13)51; (15)406; (17)101; (20)254; (23)203; (27)101; (29)101; (30)101; (31)51; (32)101; (36)558; (37)761; (43)101; (49)51; (51)51; (53)51; (74)51; (78)51; (80)51; (81)51; (83)51; (84)51; (85)51; (86)51; (87)51	31	5328	0.26
S 67	(6)8; (15)108; (17)17; (19)8; (20)8; (36)42; (37)42; (43)8; (77)8; (80)17	10	266	0.06
S 68	(3)40; (7)20; (8)198; (9)20; (10)159; (12)40; (15)139; (22)40; (25)40; (28)40; (29)40; (30)20; (31)119; (35)20; (36)298; (37)377; (38)79; (42)20; (43)40; (44)40; (45)20; (49)79; (50)20; (71)40; (72)20; (73)20; (74)20; (75)20; (76)20	29	2048	0.68
S 69	(1)12; (2)12; (8)263; (12)60; (13)24; (15)96; (20)12; (21)12; (22)24; (23)60; (28)12; (29)72; (30)24; (31)12; (34)12; (35)12; (36)72; (37)132; (38)24; (40)12; (43)72; (44)48; (45)48; (51)12; (52)12; (74)12; (79)24	27	1187	0.28
S 70	(12)16; (15)81; (17)24; (20)8; (23)8; (27)8; (28)8; (29)16; (31)8; (32)8; (35)16; (36)33; (37)154; (43)24; (52)8; (53)8	16	428	0.36
S 71	(2)220; (5)55; (6)165; (7)165; (8)440; (9)110; (10)330; (12)660; (15)275; (23)55; (25)165; (29)275; (30)165; (31)55; (32)55; (35)55; (36)1046; (37)715; (38)165; (42)55; (44)55; (49)110; (50)110; (51)55; (74)55; (77)55; (79)55; (101)55; (113)55	29	5831	0.58
S 72	(1)25; (9)25; (10)25; (12)74; (15)421; (17)99; (20)149; (23)322; (25)50; (29)25; (31)25; (32)124; (34)50; (35)173; (36)198; (37)421; (38)50; (43)99; (63)25; (77)50; (78)25; (79)25; (80)25	23	2505	0.52
S 73	(5)32; (8)291; (10)388; (12)129; (15)1035; (17)32; (20)65; (23)32; (25)97; (29)97; (31)129; (32)32; (34)32; (35)32; (36)97; (37)226; (38)32; (39)65; (45)65; (49)65; (50)32; (71)32; (77)65; (80)32; (84)65; (116)32	26	3231	0.32
S 74	(2)9; (8)9; (9)17; (10)9; (15)52; (23)17; (24)9; (25)17; (29)9; (31)17; (34)9; (35)26; (36)43; (37)112; (38)9; (42)17; (43)43; (44)9; (45)17; (74)9; (77)9; (79)9; (80)9	23	486	3.57

Table B3. Site-by-site results table for meiofaunal harpacticoid copepod communities present in the samples collected during the January 2016 *KS Endeavor* residual impact assessment survey. Species codes (in brackets) are followed by the numbers of animals belonging to that species/taxa recorded per litre sediment. The key to the species codes used is given in Table A2 in Appendix A.

Site	Identification Code and Number per Litre Sediment	Number of Species	Number of Animals
1	(2)26	1	26
2	None Observed	0	0
3	None Observed	0	0
4	None Observed	0	0
5	None Observed	0	0
6	None Observed	0	0
7	None Observed	0	0
8	(2)21	1	21
9	None Observed	0	0
10	None Observed	0	0
11	None Observed	0	0
12	(15)58	1	58
13	None Observed	0	0
14	None Observed	0	0
15	None Observed	0	0
16	(2)36; (13)18	2	54
17	None Observed	0	0
18	(2)27	1	27
19	(1)17	1	17
21	(2)62	1	62
22	None Observed	0	0
23	(2)45	1	45
24	(7)63; (13)32; (15)32; (17)32	4	159
25	(1)27; (2)27; (6)27; (7)53; (10)27; (13)53; (17)27	7	241
26	None Observed	0	0
27	None Observed	0	0
28	None Observed	0	0
29	None Observed	0	0
30	None Observed	0	0
31	(1)21	1	21
32	None Observed	0	0
33	None Observed	0	0
34	(2)31	1	31
35	(2)9	1	9
36	None Observed	0	0

Site	Identification Code and Number per Litre Sediment	Number of Species	Number of Animals
37	None Observed	0	0
38	None Observed	0	0
39	(3)43; (4)22; (5)108	3	173
40	(4)27	1	27
41	None Observed	0	0
42	(2)11	1	11
43	(6)12; (7)12	2	24
44	(8)1048; (9)175	2	1223
45	(5)16; (7)98; (8)211; (9)130; (11)195; (12)16	6	666
46	(10)17	1	17
47	None Observed	0	0
48	None Observed	0	0
49	None Observed	0	0
50	None Observed	0	0
51	None Observed	0	0
52	(2)17	1	17
53	(2)33	1	33
54	None Observed	0	0
55	(2)9	1	9
56	(3)106; (7)21; (11)106	3	233
57	(8)36; (9)72; (11)270	3	378
58	None Observed	0	0
59	(13)15	1	15
60	(14)17	1	17
61	(1)8; (2)8	2	16
62	(2)22; (15)11	2	33
63	None Observed	0	0
64	(5)8	1	8
65	(1)22; (2)44	2	66
66	(1)26; (2)13; (5)13; (13)13; (15)13; (16)13	6	91
67	None Observed	0	0
68	None Observed	0	0
69	(1)8	1	8
70	None Observed	0	0
71	(1)17	1	17
72	None Observed	0	0
73	None Observed	0	0
74	None Observed	0	0

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Appendix C

Distributions of the Invertebrate Community Parameters within the O˜ shore Survey Area

Physalia

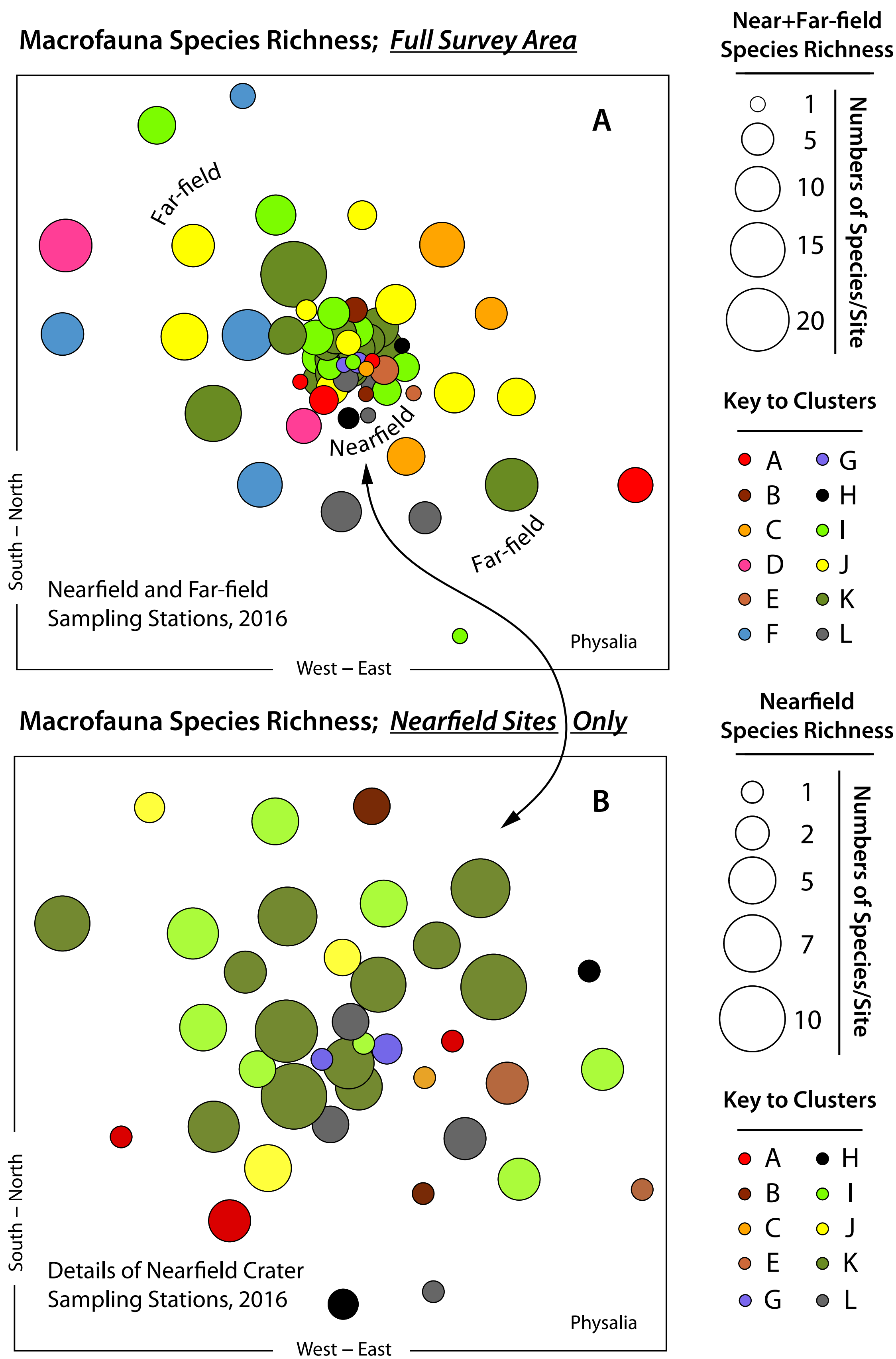

Figure C1. Plots showing the numbers of species (= *species richness*) present at each of the sampling stations examined in the full survey area (i.e. combined near- and far-field sites; Figure A) and in the central section of the survey area (i.e. near-field sites; Figure B). Colours relate to clusters of co-occurring communities of species.

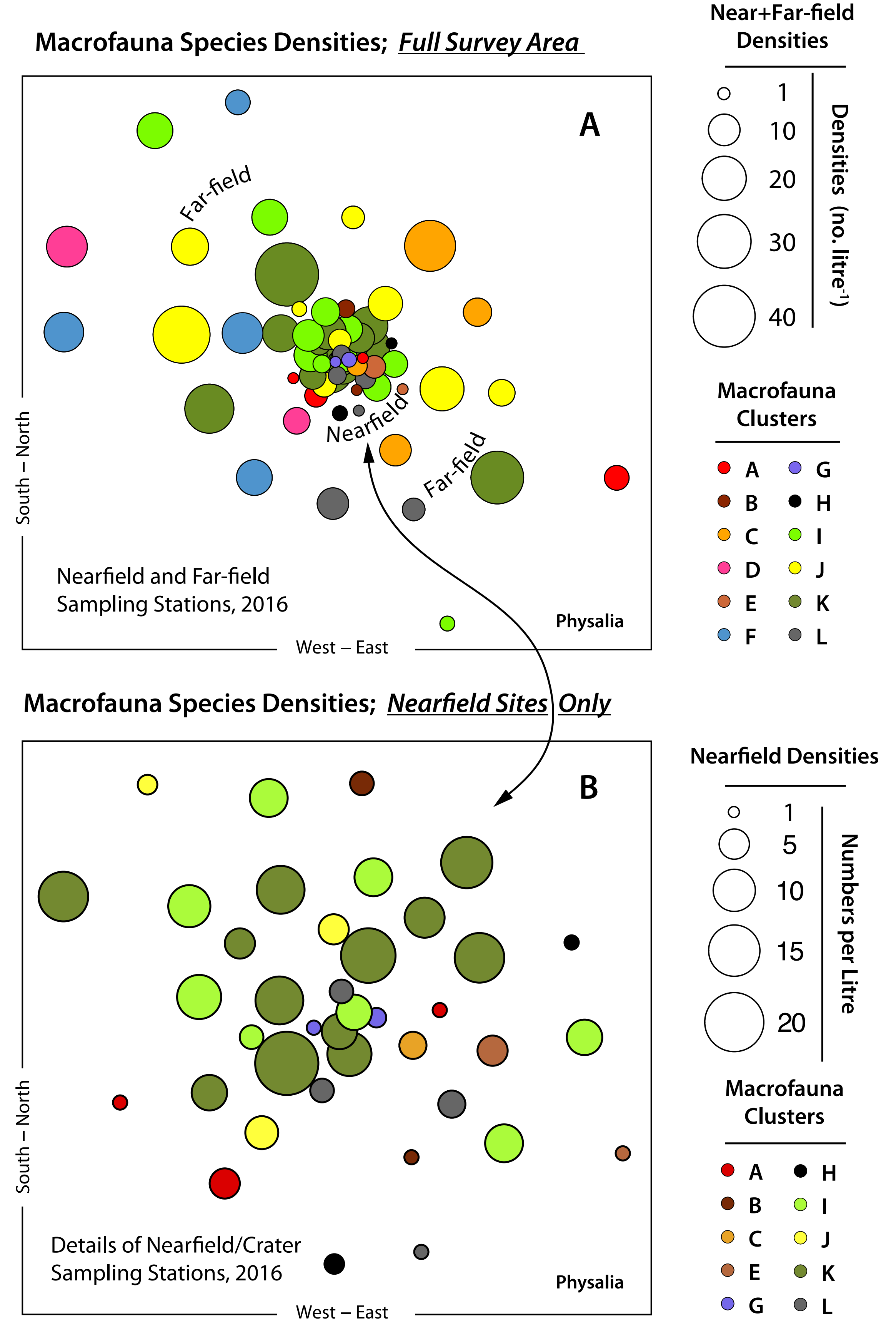

Figure C2. Plots of densities and clusters of structurally-related macrofaunal invertebrate communities that reflect prevailing sediment conditions in **A).** the full survey area (near + far-field sites) and **B).** the incident epicentre comprising a deep blow-out site surrounded by ejected crater sediments (= nearfield). Colours relate to clusters of co-occurring communities of species.

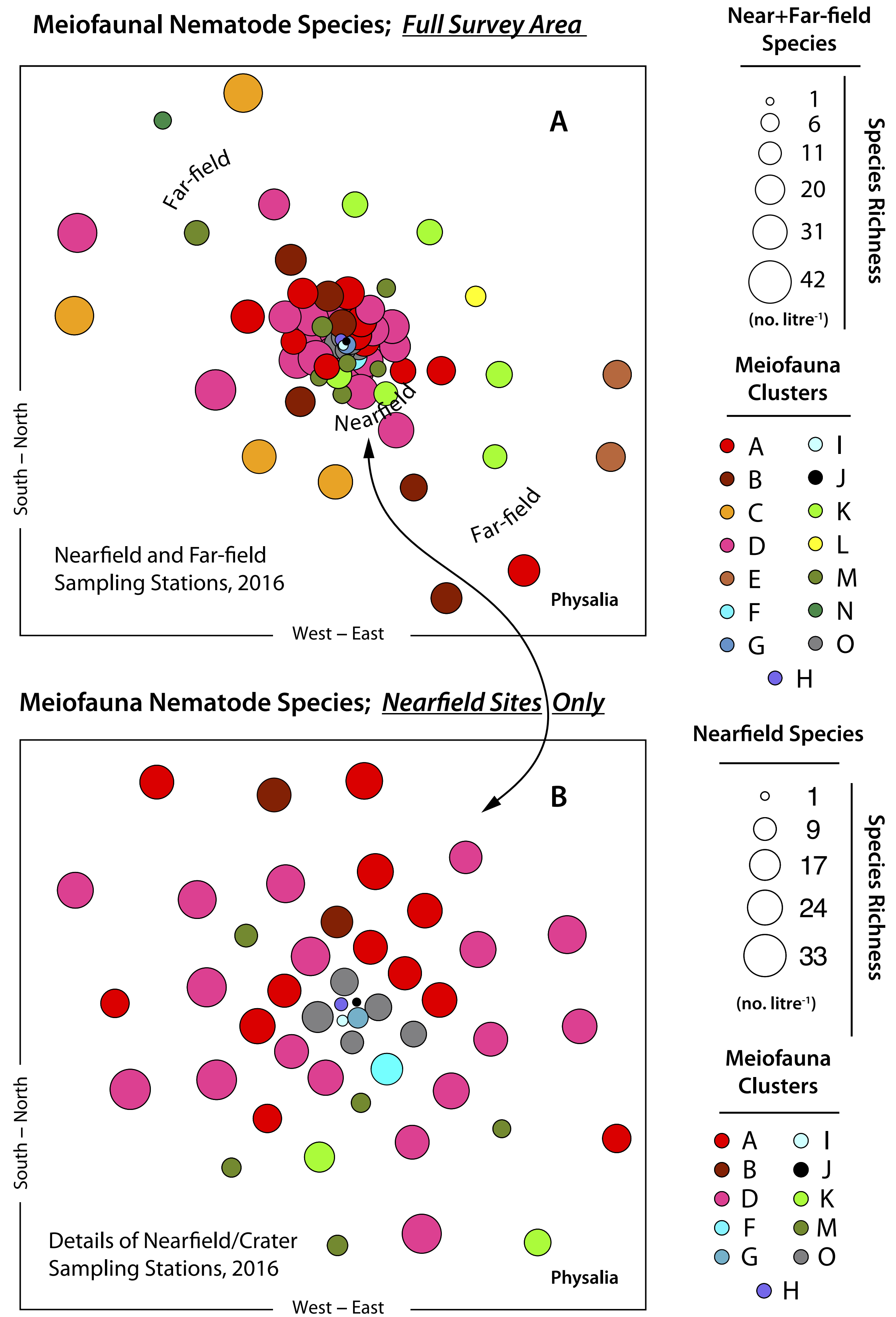

Figure C3. Plots showing the distributions of the meiofaunal nematode species and the multi-variate clusters of structurally-related nematode communities reflecting prevailing sediment conditions in **A).** the full survey area (near + far-field sites) and **B).** the incident epicentre comprising a deep blow-out site surrounded by ejected crater sediments (= nearfield). Coloured symbols relate to clusters of co-occurring communities of species.

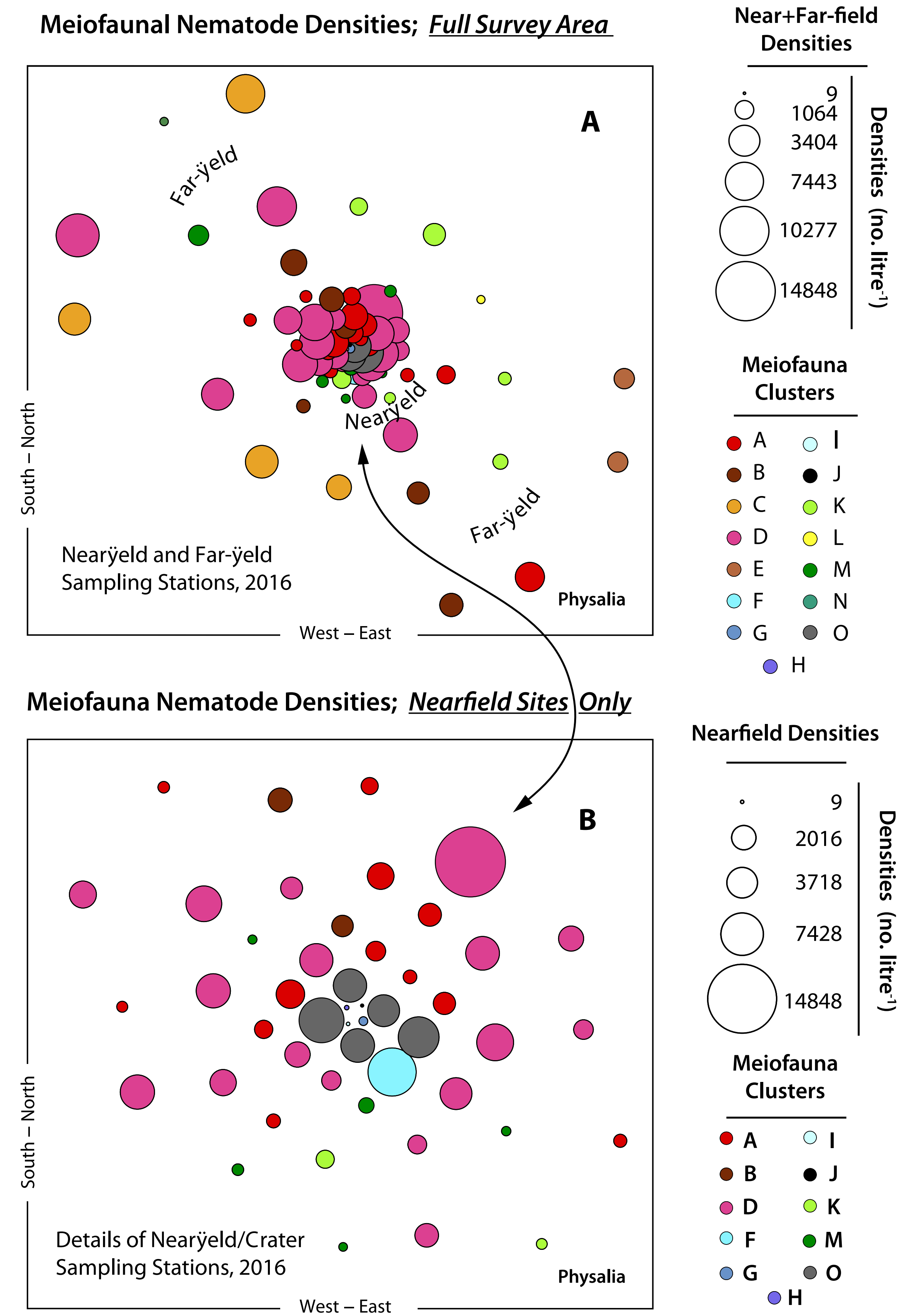

Figure C4. Plots showing the distributions of densities of the meiofaunal nematode species and the multivariate clusters of structurally-related meiofaunal nematode communities re˜ec ting prevailing sediment conditions in **A).** the full survey area (near + far-ÿeld sites) and **B).** the incident epicentre comprising a deep blow-out site surrounded by ejected crater sediments (= nearÿeld). Coloured symbols relate to clusters of co-occurring communities of species.

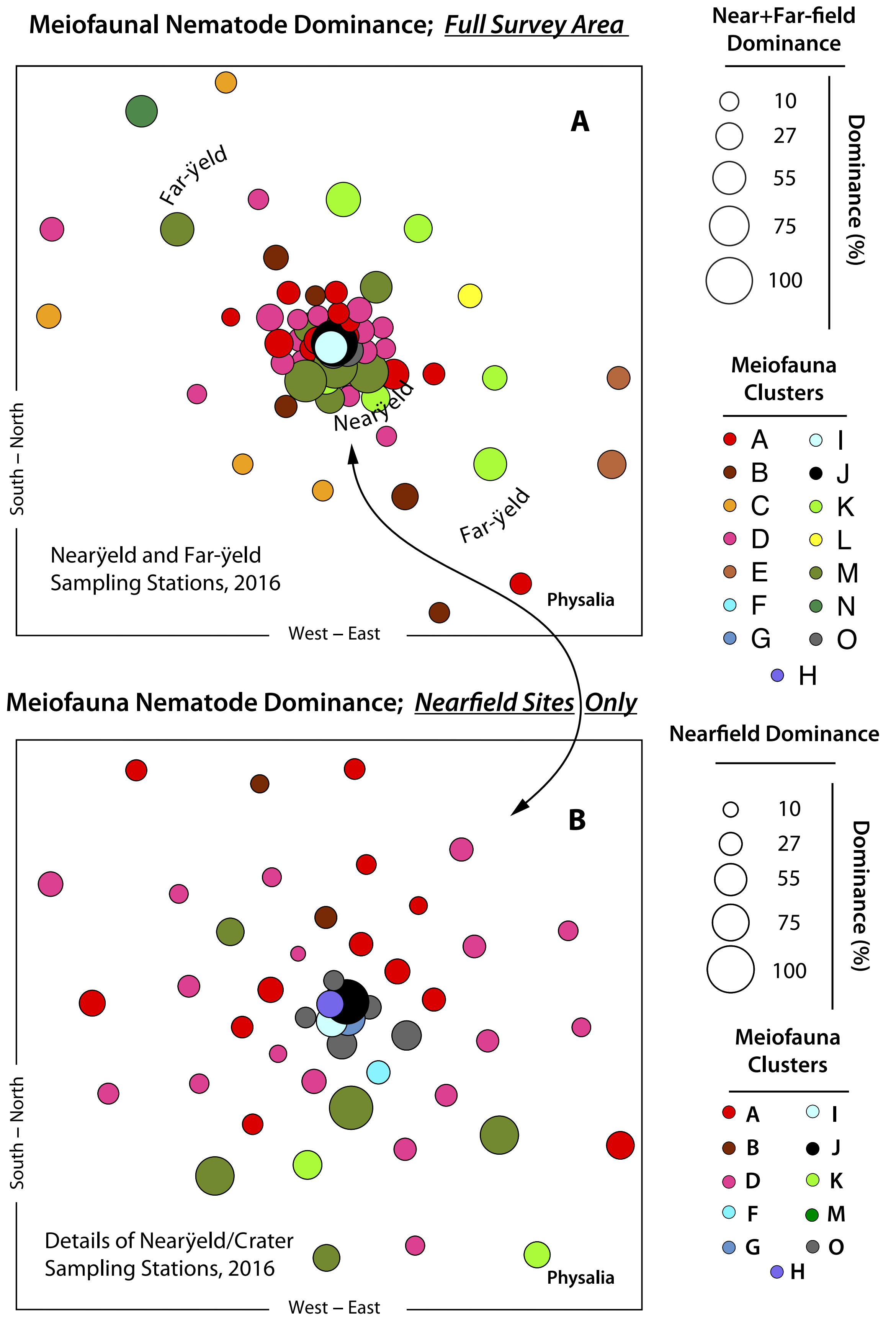

Figure C5. Meiofaunal nematode dominance values annotated with the colour-coded, multivariate clusters that identify structurally-related meiofaunal nematode communities re˜ec ting prevailing sediment conditions on the seabed. **A)** full survey area (near + far-ÿeld sites) and **B)** nearÿeld incident epicentre comprising the deep blow-out crater and surrounding, ejected crater sediments.

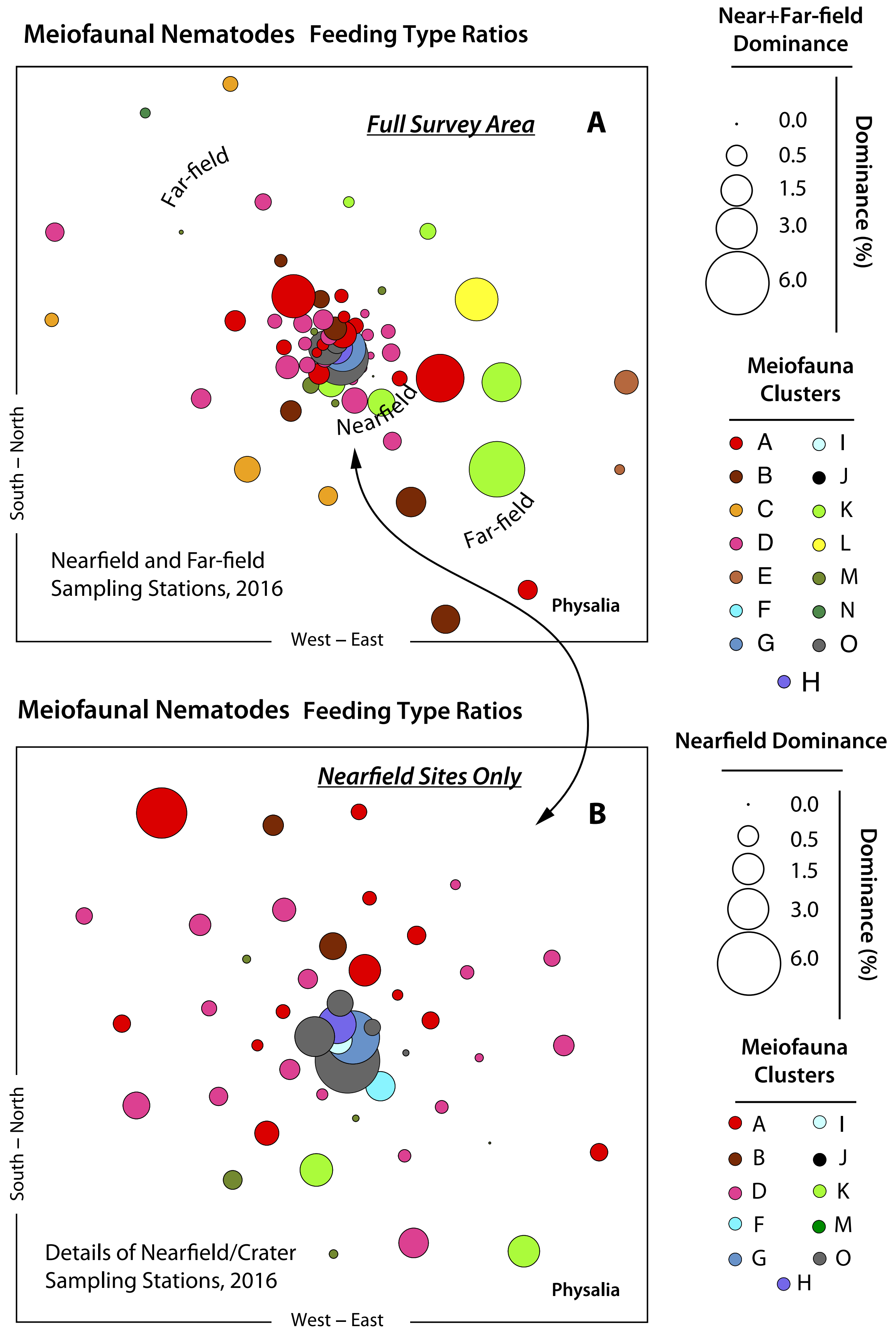

Figure C6. Meiofaunal nematode feeding type ratios annotated with the colour-coded, multivariate clusters that identify structurally-related meiofaunal nematode communities reflecting prevailing sediment conditions on the seabed. **A)** full survey area (near + far-field sites) and **B)** nearfield incident epicentre comprising the deep blow-out crater and surrounding, ejected crater sediments.

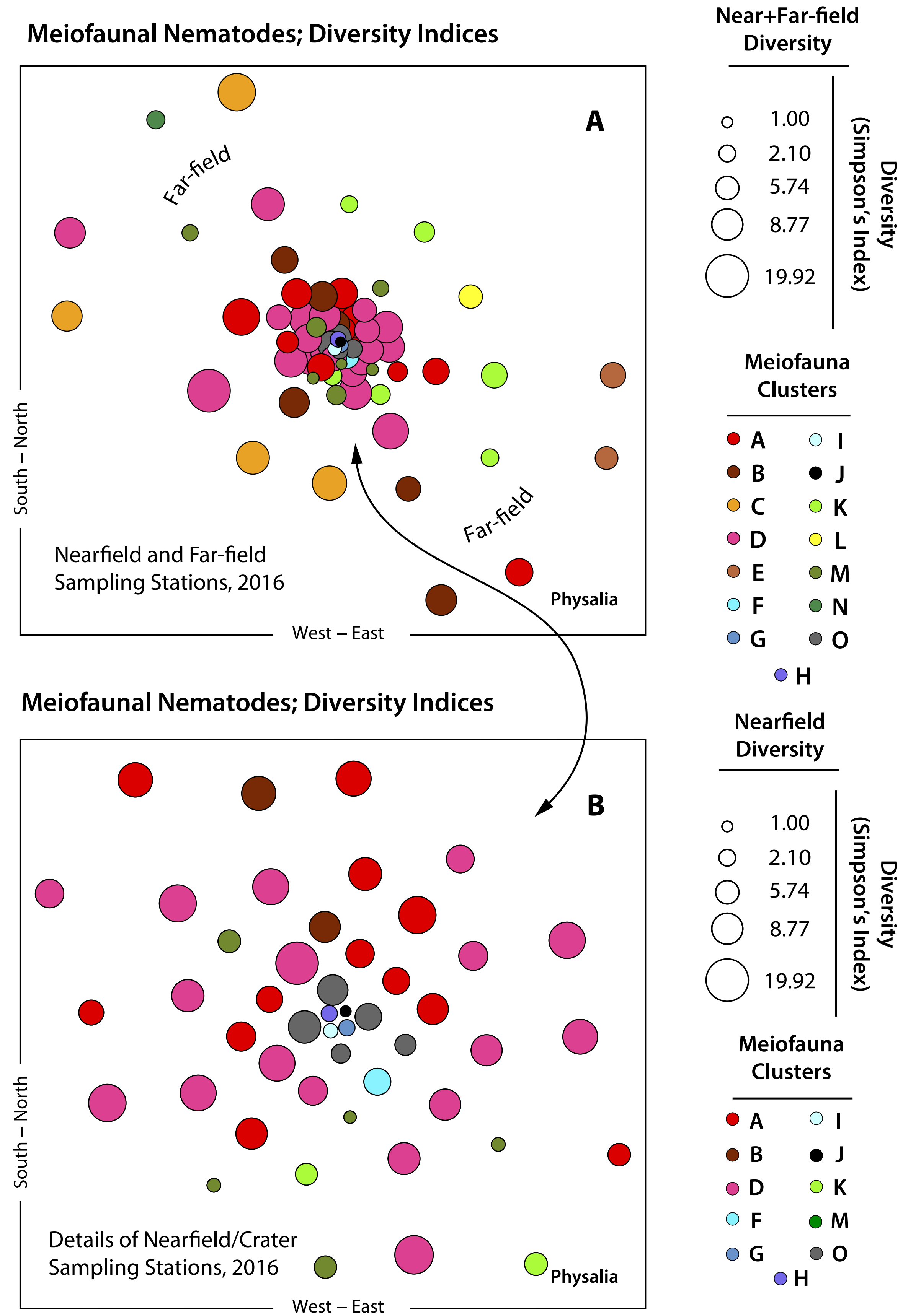

Figure C7. Meiofaunal nematode diversity (Simpson's index) annotated with the colour-coded, multivariate clusters that identify structurally-related meiofaunal nematode communities reflecting prevailing sediment conditions on the seabed. **A)** full survey area (near + far-field sites) and **B)** nearfield, incident epicentre comprising the deep blow-out crater and surrounding, ejected crater sediments.

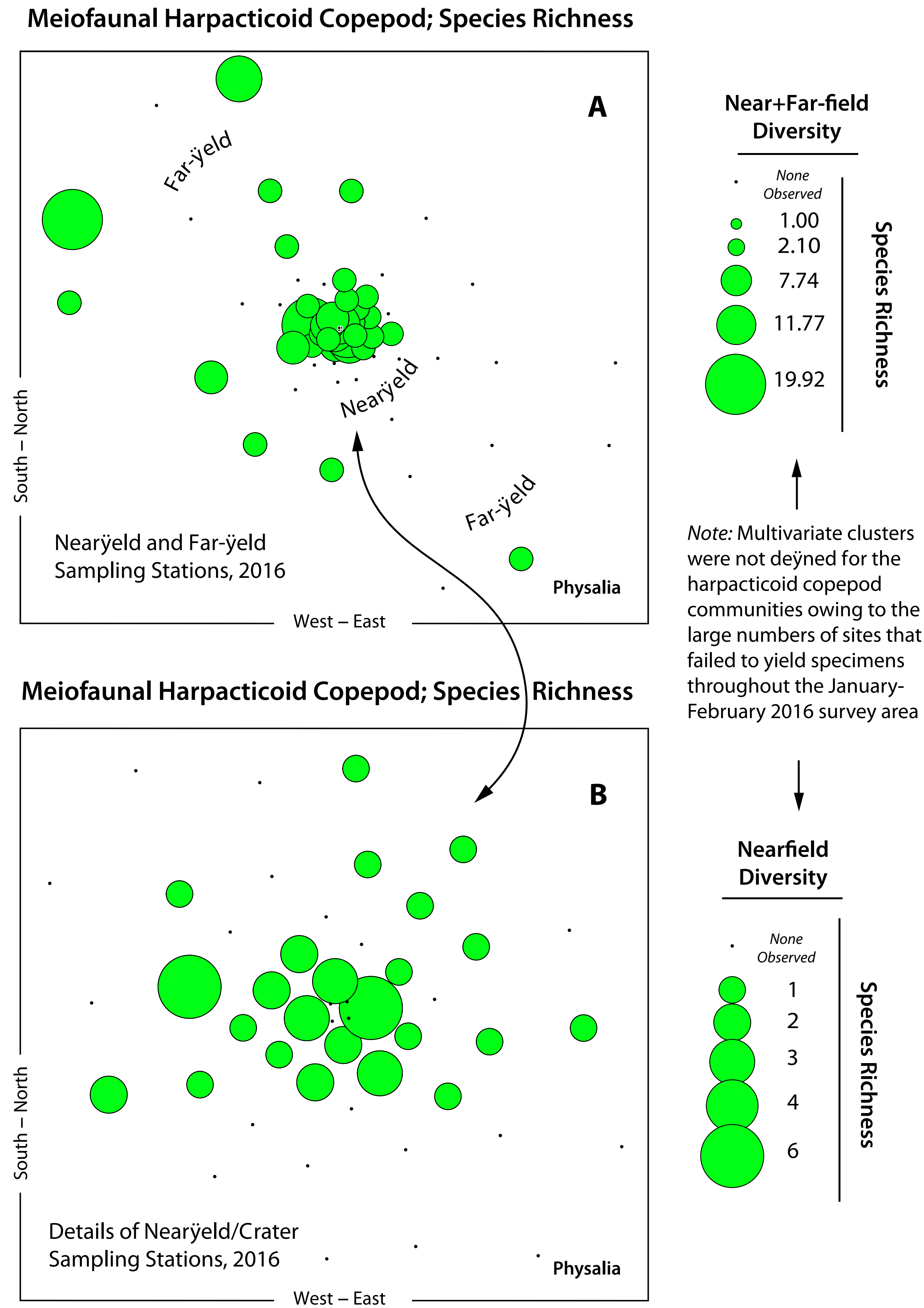

Figure C8. Meiofaunal harpacticoid copepod species richness. Note that these data were not annotated with the colour-coded, multivariate clusters that identify structurally-related copepod communities owing to their low densities and the relatively large number of sites at which no copepods were recorded. **A)** full survey area (near- and far-ÿeld sites) and **B)** nearÿeld, incident epicentre sites comprising the deep blow-out crater and surrounding, ejected crater sediments.

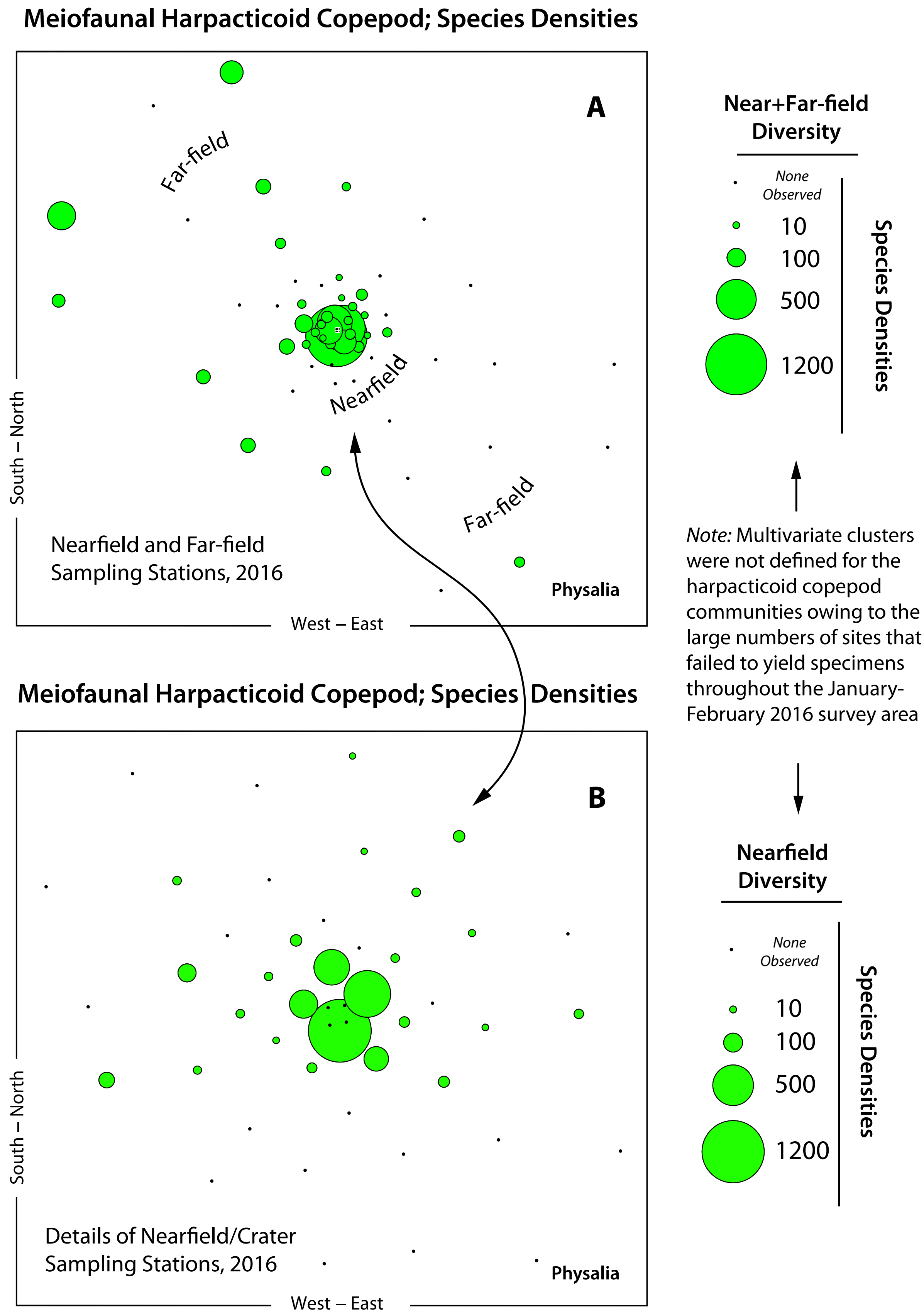

Figure C9. Meiofaunal harpacticoid copepod species densities. Note that these data were not annotated with the colour-coded, multivariate clusters that identify structurally-related copepod communities owing to their low densities and the relatively large number of sites at which no copepods were recorded. **A)** full survey area (near- and far-field sites) and **B)** nearfield, incident epicentre sites comprising the deep blow-out crater and surrounding, ejected crater sediments.

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Appendix D

Multivariate Analyses of Community Structures as the Basis for Describing and Assessing the Status of Benthic Assemblages

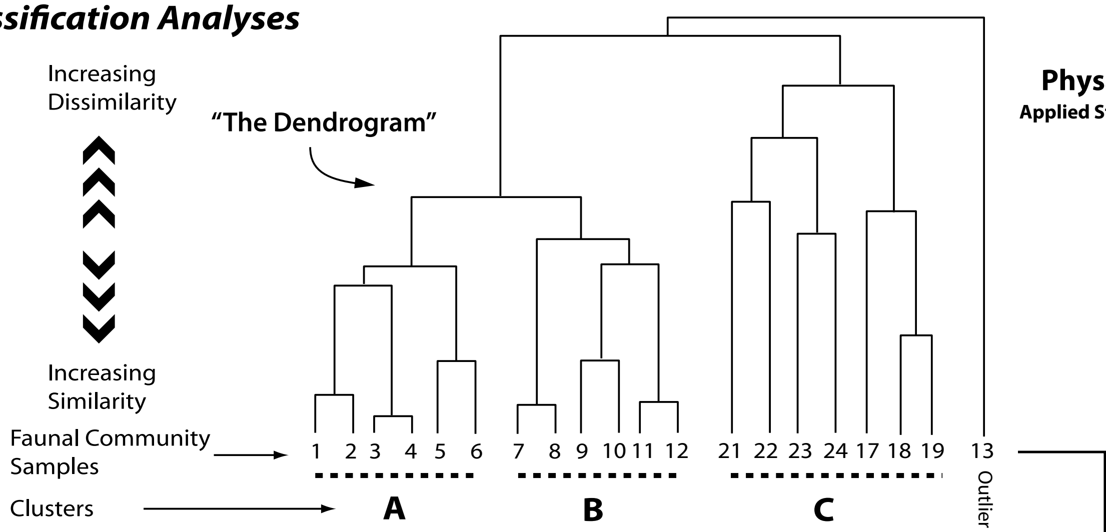
Physalia

Table D1. Interpretation of Summary Outputs from the Multivariate Analyses

Physalia
Applied Statistics

■ *Classification Analyses*

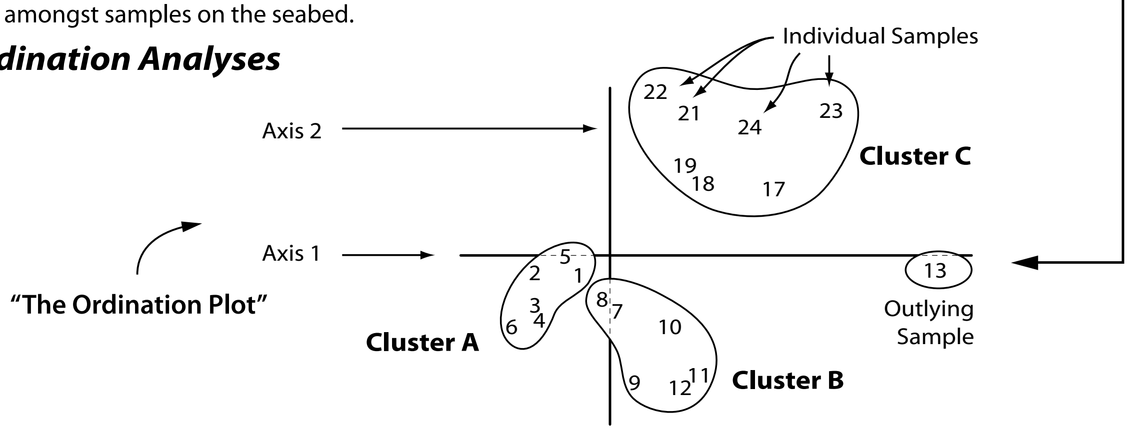
First Cycle of Analyses



Classi ication analyses, the greater the similarity between the samples (based on their species or chemistry and their densities/concentrations), the closer they are linked to one another and *vice versa*. This is shown in the different lengths of inter-connecting lines. Here, the biological samples 1 to 6 form Cluster A and are structurally ("ecologically") more similar to each other than they are to samples 7 to 12 (Cluster B). In turn, Cluster A and B samples are more closely related to each other than they are to those samples in Cluster C. Sample13 is highly distinctive and forms an "outlier". In this report we use also use <u>two-way classification analyse</u>s for chemistry data. These analyses group the elements together based on the samples in which they occur and the concentrations at which they were present. This produces a matrix that helps in the interpretation of contaminant distributions amongst samples on the seabed.

■ *Ordination Analyses*

Second Cycle of Analyses



Ordination Analyses award scores to each sample based on multiple community or sediment chemistry variables (i.e. species/elements present in each sample and their densities/concentrations). The scores are used to spread samples along two (or more) axes of variation such that structurally-similar samples are grouped together whilst dissimilar samples are separated by greater distances. This approach uses an entirely different mathematical methodology to the classification analyses, ordination analyses and is therefore used to confirm the findings of the multivariate analyses; a process called "coherence testing". Once confirmed, clusters are plotted onto maps or displayed in 3-dimensional reconstructions to aid interpretation of effects of prevailing conditions on communities. A key of bioindicators (e.g. meiofauna) is that this enables changes to be identified, described/quantified and tracked over time e.g. in post-remediation works or in post-incident works.

Fingerprinting

Indicator and Multivariate Correlation Analyses identify measured environmental factors whose presence and concentrations/magnitudes are statistically significantly correlated with community structures. Performed using Monte Carlo permutation tests, these define statistically significant "physico-chemical signatures" that identify/track the causes of changes in the biosensor communities.

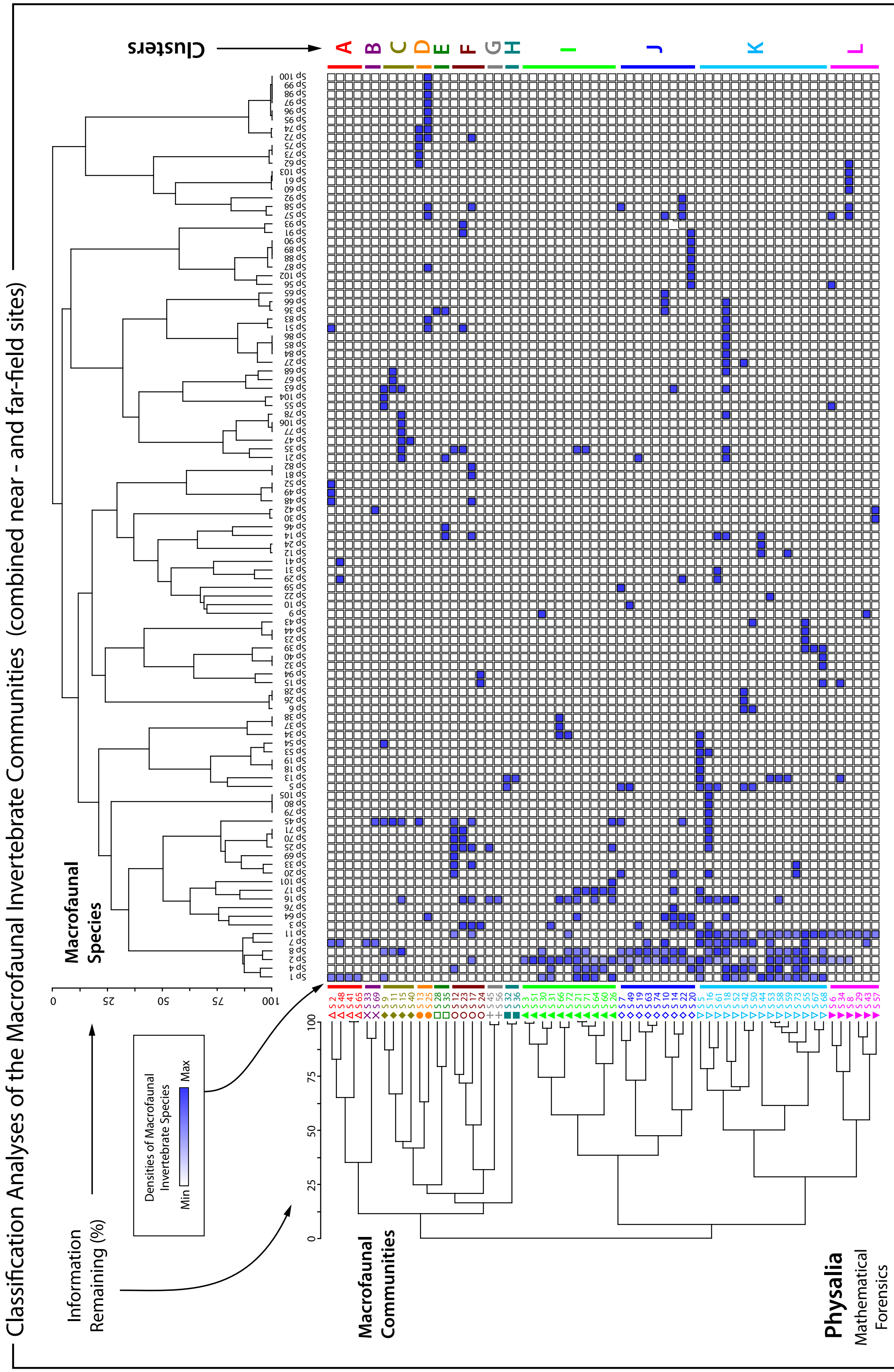


Figure D2 Classification analyses ("two-way" dendrograms and species density matrices) showing the relationships between the macrofaunal species and the communities and their densities in the 2016 near and far-field survey area. See text for discussion.

Macrofaunal Indicator Species

Species code	Species/Taxon	Cluster Letter	IV	Mean	S.Dev	*p*-Value
Species 47	*Iphinöe* species cf. *I. senegalensis*	**C**	50.0	21.4	14.03	0.0114
Species 63	Pyrimadellidae species 3	**C**	62.6	20.5	10.97	0.0168
Species 74	*Eulimella* species (cf. *E.˜agellum*)	**D**	100.0	21.2	13.86	0.0036
Species 72	*Globigerina* species	**D**	83.8	21.6	12.93	0.0080
Species 36	Tellinid species (probably *Tellina* species)	**E**	84.9	20.8	11.22	0.0036
Species 71	*Cuspidaria abbreviata*	**F**	45.3	21.1	12.45	0.0122
Species 70	*Caviolinia* species	**F**	45.9	20.9	12.62	0.0128
Species 3	*Cirratulus* species	**F**	53.5	18.6	10.13	0.0190
Species 25	*Scolelepis squamata*	**F**	43.3	19.3	10.42	0.0368
Species 33	*Scoloplos armiger*	**F**	41.3	21.4	12.41	0.0426
Species 13	Nemertean (family Lineidae)	**H**	67.9	19.1	10.26	0.0036
Species 2	Pectinariidae species	**I**	34.1	16.1	3.28	0.0002
Species 8	*Notomastus* species	**J**	30.0	17.4	6.52	0.0336
Species 11	*Nephthys sphaerocirrata*	**K**	41.4	17.4	6.74	0.0004

Table D2. List of the species of macrofaunal invertebrates whose presence and abundances were shown to be statistically significantly related to given clusters identified in the multi-variate analyses.

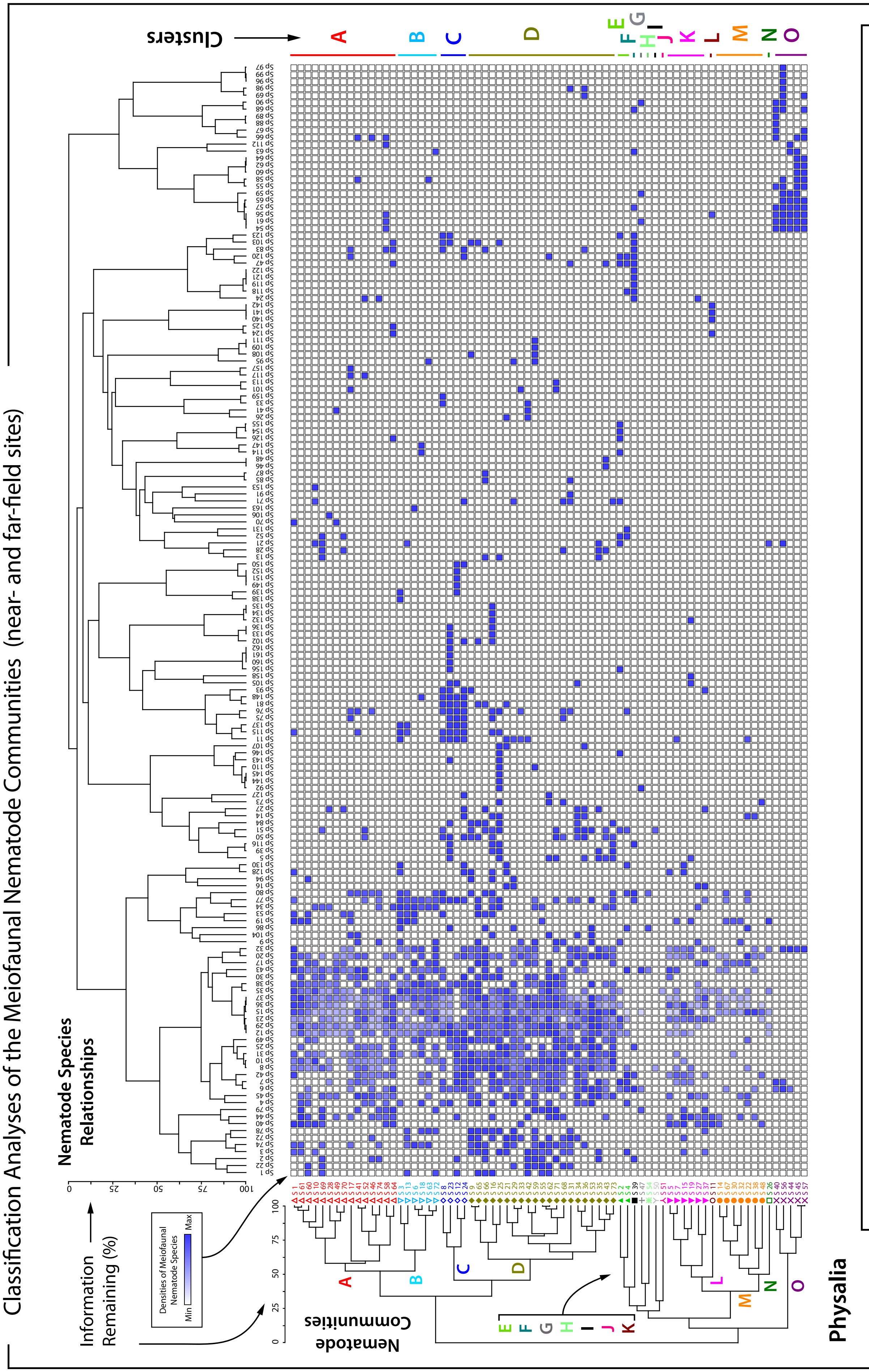


Figure D3. "Two-way" dendrograms and species density matrices (= classification analyses) showing the relationships between the meiofaunal nematode species and the communities along with their densities in the near- and far-field survey area. See main text for full details.

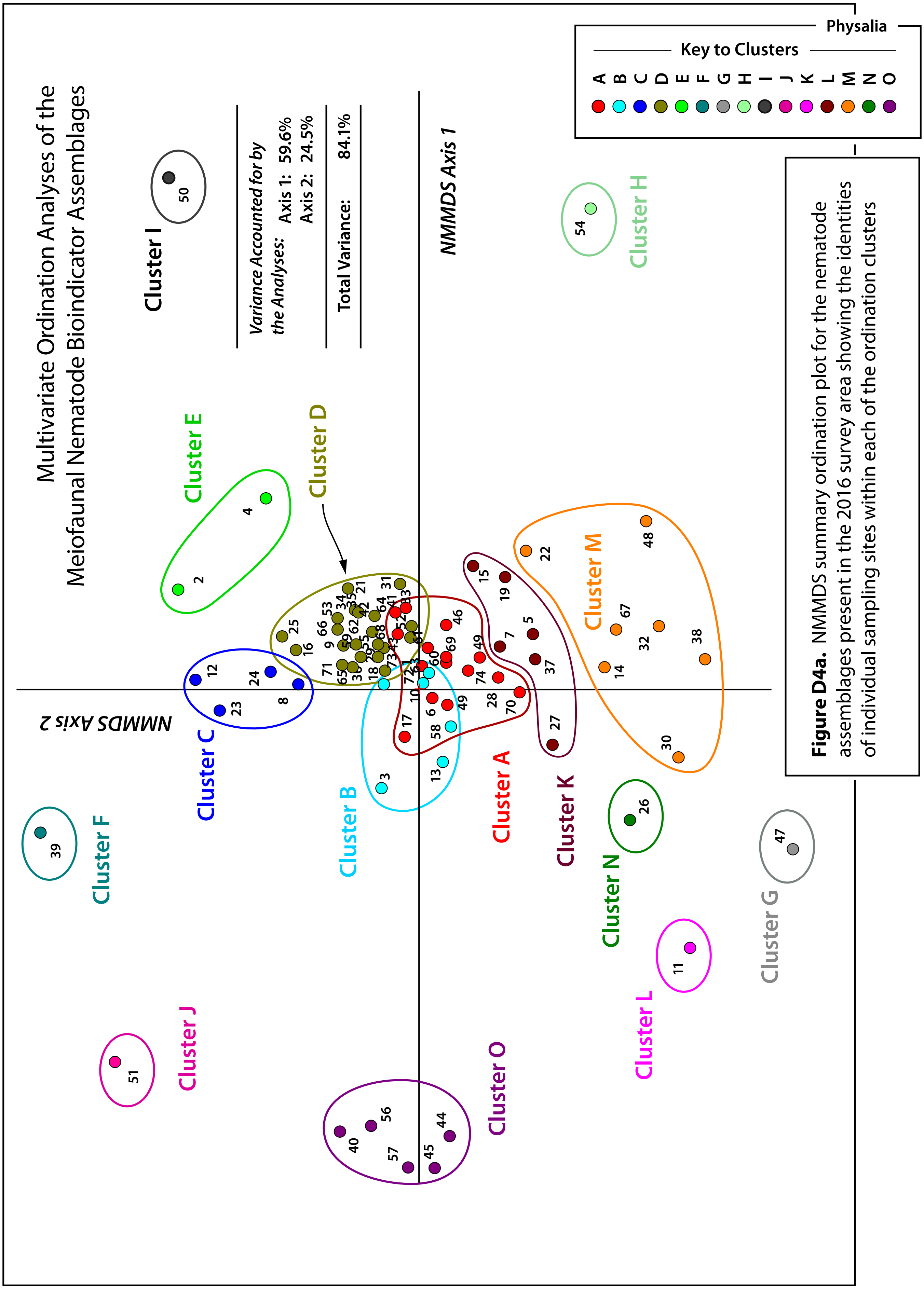


Figure D4a. NMMDS summary ordination plot for the nematode assemblages present in the 2016 survey area showing the identities of individual sampling sites within each of the ordination clusters

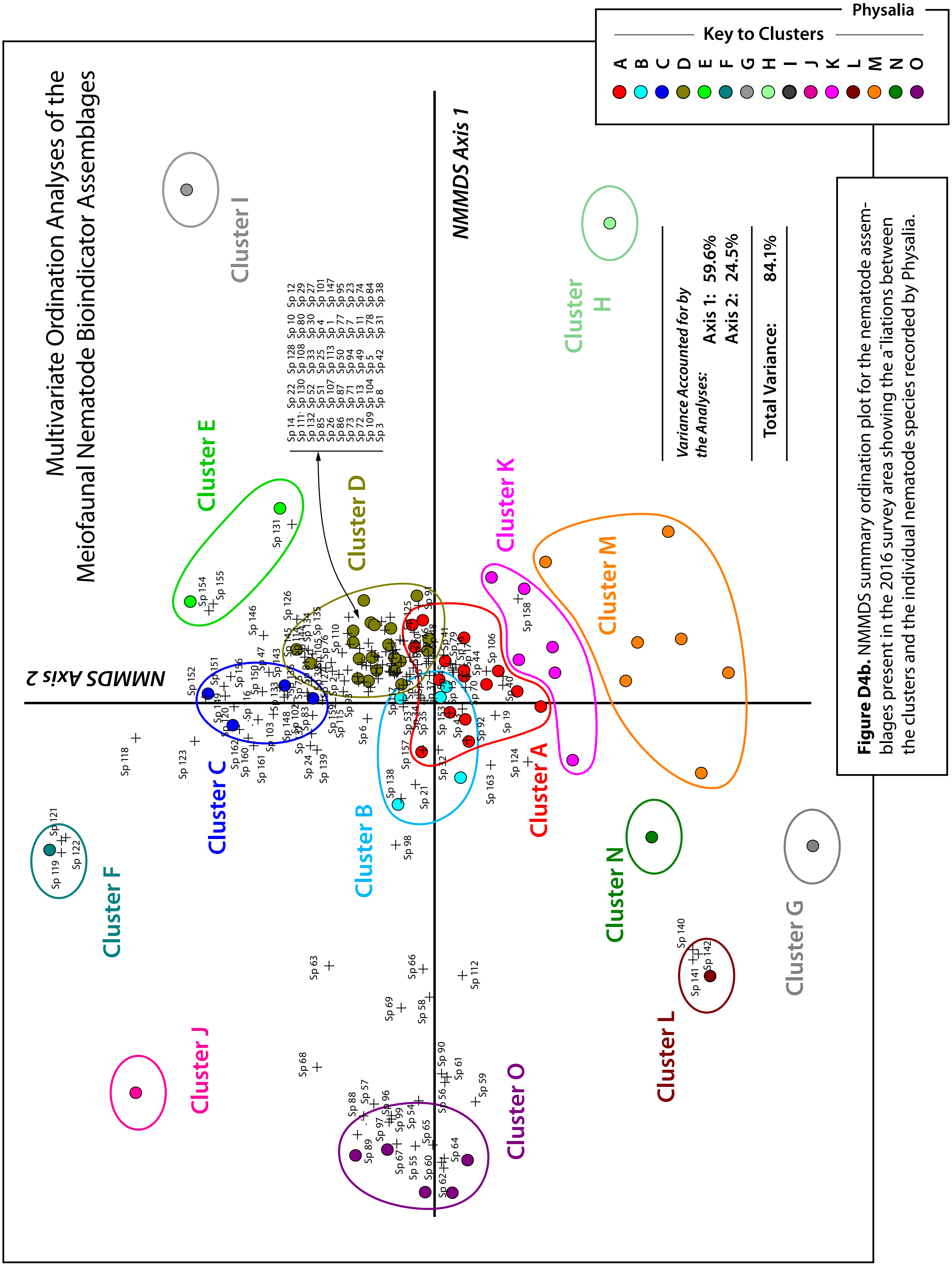


Figure D4b. NMMDS summary ordination plot for the nematode assemblages present in the 2016 survey area showing the a˝liations between the clusters and the individual nematode species recorded by Physalia.

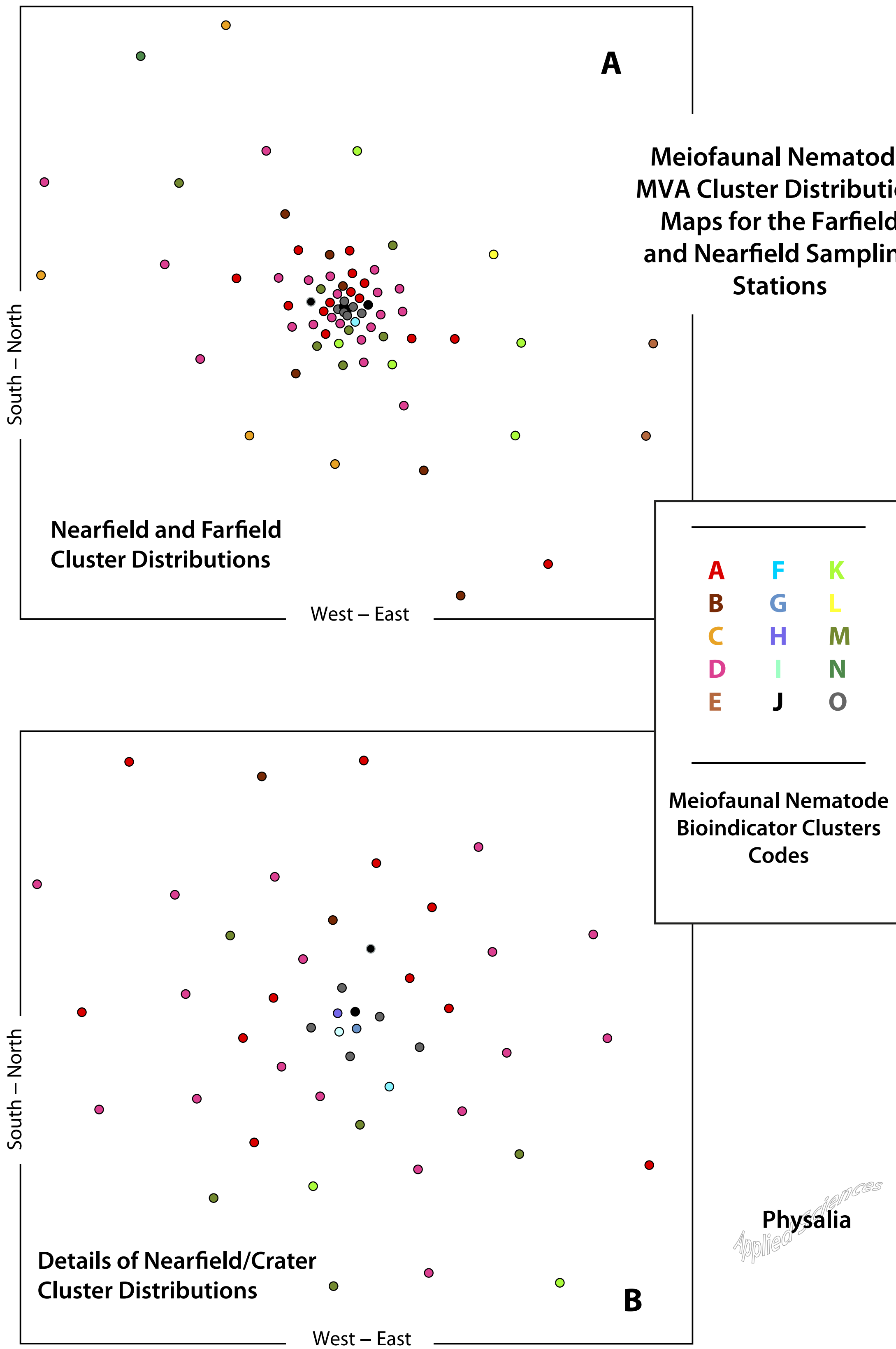


Figure D5. Distributions of the multivariate clusters of structurally-related meiofaunal nematode bio-indicator species assemblages. The cluster plots show (A) near ÿeld *and* far ÿeld nematode communities and (B) details of the clusters of related species in the near ÿeld (central section) of the survey area

Cluster	Species Code	Species/Taxon Identity	Indicator Value	*p*-Value
B	Sp 34	*Metalinhomoeus* species 2	58.7	0.0002
B	Sp 37	*Terchellingia* species 2	22.5	0.0002
B	Sp 35	*Terchellingia* longicaudata	26.8	0.0018
B	Sp 38	*Terchellingia* species 3	32.4	0.0028
B	Sp 78	*Axonolaimus* species	35.0	0.044
C	Sp 12	*Vastostoma* species 1	26.0	0.0002
C	Sp 81	*Pselionema* species 1	89.0	0.0002
C	Sp 115	*Paralongicyatholaimus* species	67.5	0.0002
C	Sp 77	*Synonchiella* species *?S. reimanni*	41.9	0.0006
C	Sp 148	*Leptonemoides* species 4	87.5	0.0006
C	Sp 11	*Sabatieria* species 2	63.9	0.0014
C	Sp 76	*Daptonema oxycerca*	58.0	0.003
C	Sp 150	*Neochromadora* species 3	50.0	0.0038
C	Sp 93	*Cheironchus* species	61.3	0.0046
C	Sp 75	*Sphaerolaimus* species 3	63.5	0.0062
C	Sp 102	*Dorylaimopsis* species	42.6	0.0062
C	Sp 137	*Vastostoma* species 2	55.2	0.0064
C	Sp 50	*Quadricoma* species	46.9	0.0134
C	Sp 103	*Marylynnia* species *?M. complexa*	35.3	0.0158
C	Sp 83	*Viscosia* species *V. elegans*	35.4	0.0188
C	Sp 105	*Quadricoma* species	37.9	0.0194
D	Sp 8	*Chromaspirina* species	33.1	0.0002
D	Sp 10	*Sabatieria* species 1	36.6	0.0002
D	Sp 15	*Comesa* species 1 *?C. cuanensis*	19.9	0.0002
D	Sp 29	*Campylaimus* species 1	25.1	0.0002
D	Sp 36	*Terchellingia* species 1	20.7	0.0008
D	Sp 72	*Halalaimus* species 2 *?H. isaitshikovi*	35.1	0.0416
E	Sp 52	*Geomonhystera* species *?G. ÿlicaudata*	91.7	0.0006
E	Sp 47	*Campylaimus* species 2	86.5	0.0008
E	Sp 7	*Pomponema* species	30.2	0.004
E	Sp 120	*Pseudosteineria* species	68.7	0.0064
E	Sp 51	*Richtersia* species 1 *?R. pilosa*	50.4	0.0074
E	Sp 126	Oncholaimidae species	45.3	0.021
E	Sp 154	Leptolaimidae species 3	50.0	0.028
E	Sp 155	*Pterygonema* species 1	50.0	0.028
E	Sp 146	*Microlaimus* species 1 *?M. acinaces*	44.7	0.0316
E	Sp 118	*Daptonema* species 4	50.0	0.0326
E	Sp 131	*Metadesmolaimus* species 2	50.0	0.0326
K	Sp 40	*Sphaerolaimus* species 1	42.4	0.0254
K	Sp 23	*Leptolaimus* species 1 *?L. limicolus*	21.2	0.0306
O	Sp 54	*Ceramonema* species 1	96.8	0.0002
O	Sp 56	*Rhynchonema* species	95.8	0.0002
O	Sp 57	*Paracyatholaimus* species *?P. multispiralis*	100.0	0.0002
O	Sp 61	*Xyala* species 1	96.5	0.0002
O	Sp 59	*Enoplolaimus* species	60.0	0.0014
O	Sp 55	*Paracanthonchus* species 1 *?P. longus*	80.0	0.002
O	Sp 68	*Metadasynemoides* species 1	60.0	0.002
O	Sp 65	*Bathylaimus* species	80.0	0.003
O	Sp 66	*Neochromadora* species 1	50.2	0.0056
O	Sp 58	*Oncholaimus* species	46.4	0.0074
O	Sp 60	*Rhabdocoma* species	40.0	0.0436
O	Sp 90	*Ceramonema* species 4	40.0	0.0442
O	Sp 67	*Ceramonema* species 2	40.0	0.0446
O	Sp 62	*Paracanthochus* species 2	40.0	0.0464
O	Sp 64	*Enoploides* species	40.0	0.0464

Table D3. List of indicator species exhibiting statistically significant associations with the clusters of meiofaunal nematode communities described in the *KS Endeavor* 2016 survey area. Data were derived from Monte Carlo permutation test-based indicator species analyses (ISAs). *p*-Values shown relate to the associations between species and their respective clusters.

Physalia

KS Endeavor Blowout Incident; Residual Marine Benthic Impact Assessment January - February 2016

Appendix E

The Physico-chemistry of the Seabed Habitats in the January - February 2016 Survey Area

Physalia

Particle Size Fractions (µm)

Coarse ⟵⟶ *Fine*

Sampling Station	> 2000 µm	1000-2000 µm	500 - 1000 µm	250-500 µm	125-250 µm	63-125 µm	< 63 µm
1	0.00	0.00	0.04	0.02	0.66	3.47	95.80
2	0.02	0.00	0.03	0.03	0.32	11.76	87.84
3	0.00	0.00	0.07	0.44	5.40	6.20	87.89
4	0.00	0.00	0.02	0.36	0.93	75.14	23.55
5	0.00	0.00	0.06	0.06	0.43	1.84	97.60
6	0.04	0.02	0.04	0.35	2.18	4.32	93.05
7	0.00	0.00	0.00	0.05	0.34	1.38	98.24
8	0.06	0.25	0.61	1.31	4.38	12.79	80.60
9	0.00	0.00	0.04	0.08	0.78	3.19	95.91
10	0.00	0.00	0.03	0.06	0.73	3.36	95.82
11	0.00	0.00	0.00	0.02	0.33	6.29	93.36
12	3.37	1.03	1.07	2.04	1.63	8.05	82.82
13	0.14	0.04	0.16	0.68	2.45	6.99	89.55
14	0.00	0.00	0.02	0.04	0.12	0.14	99.67
15	0.00	0.00	0.02	0.02	0.38	15.25	84.34
16	2.48	1.02	0.93	2.22	6.58	17.62	69.15
17	0.00	0.00	0.03	0.27	2.00	10.29	87.41
18	0.00	0.00	0.01	0.06	0.15	2.27	97.50
19	0.00	0.00	0.02	0.07	0.34	6.54	93.03
20	0.00	0.00	0.05	0.22	1.24	11.81	86.68
21	0.00	0.00	0.02	0.04	0.66	1.14	98.14
22	0.00	0.00	0.05	0.10	0.60	3.67	95.59
23	1.07	0.58	0.65	1.10	4.20	11.42	80.96
24	0.00	0.00	0.07	0.36	0.59	0.59	98.39
25	0.52	0.56	0.57	1.09	4.16	9.57	83.52
26	0.00	0.00	0.19	0.03	0.28	1.38	98.12
27	0.00	0.00	0.02	0.12	0.31	0.46	99.09
28	0.00	0.00	0.06	0.18	0.66	4.14	94.96
29	0.00	0.00	0.00	0.04	0.52	4.08	95.36
30	0.00	0.02	0.04	0.13	1.23	6.48	92.10
31	0.00	0.00	0.03	0.06	0.17	1.30	98.45
32	0.04	0.00	0.02	0.13	1.03	6.90	91.89
33	0.00	0.00	0.05	0.11	0.05	0.53	99.26
34	0.00	0.02	0.00	0.09	0.63	3.72	95.54
35	0.00	0.00	0.00	0.09	7.69	15.27	76.95
36	0.00	0.00	0.15	0.30	8.00	54.34	37.21
37	0.00	0.00	0.05	0.16	0.46	4.43	94.89

Physalia

Table E1a. Sediment particle size fractions in the *KS Endeavor* near- and far-ÿeld survey areas. Values presented as % dry weight of each particle size fraction ... *continued*

Particle Size Fractions (µm)

Coarse ← → *Fine*

Sampling Station	> 2000 µm	1000-2000 µm	500 - 1000 µm	250-500 µm	125-250 µm	63-125 µm	< 63 µm
S 35	0.00	0.00	0.00	0.09	7.69	15.27	76.95
S 36	0.00	0.00	0.15	0.30	8.00	54.34	37.21
S 37	0.00	0.00	0.05	0.16	0.46	4.43	94.89
S 38	0.00	0.00	0.00	0.06	4.61	15.01	80.33
S 39	0.06	0.00	0.06	4.76	49.60	42.86	2.66
S 40	0.02	0.00	0.42	4.87	58.81	35.89	0.00
S 41	0.00	0.00	0.02	1.83	28.63	10.33	59.19
S 42	0.00	0.00	0.07	1.21	23.52	12.15	63.06
S 43	0.00	0.00	0.00	0.35	4.33	7.83	87.50
S 44	0.11	0.00	14.63	57.16	26.43	1.66	0.00
S 45	0.34	0.00	16.58	50.53	29.56	3.00	0.00
S 46	0.00	0.00	0.27	0.27	0.54	1.41	97.50
S 47	0.00	0.00	9.60	37.00	43.16	6.02	4.21
S 48	0.00	0.00	0.02	0.17	0.29	0.86	98.66
S 49	0.00	0.00	0.02	0.07	0.31	1.35	98.25
S 50	0.00	0.00	0.00	0.02	0.32	2.37	97.29
S 51	0.00	0.00	10.95	22.32	14.53	8.35	43.84
S 52	0.00	0.00	0.04	0.60	16.10	11.00	72.27
S 53	0.00	0.03	0.03	0.34	6.86	3.14	89.60
S 54	0.04	0.00	0.11	1.06	19.94	11.31	67.54
S 55	0.00	0.00	0.00	0.14	2.17	4.39	93.29
S 56	0.03	0.02	0.03	13.15	69.61	16.69	0.47
S 57	0.07	0.82	7.15	42.61	44.91	4.43	0.00
S 58	0.00	0.00	0.58	9.80	17.20	2.64	69.78
S 59	0.02	0.00	0.08	0.24	2.36	3.83	93.48
S 60	0.00	0.00	0.02	0.09	1.61	1.68	96.59
S 61	0.00	0.00	0.02	0.07	0.24	1.68	97.99
S 62	0.05	0.00	0.06	1.35	18.86	10.57	69.11
S 63	0.61	0.00	0.03	0.49	1.13	0.20	97.53
S 64	0.00	0.00	0.22	1.78	2.91	0.72	94.37
S 65	0.40	0.37	0.32	0.65	2.11	4.02	92.12
S 66	0.00	0.00	0.22	0.06	0.19	0.88	98.64
S 67	0.00	0.00	0.02	0.07	0.46	1.18	98.27
S 68	0.08	0.05	0.05	0.00	0.25	1.42	98.14
S 69	0.00	0.00	0.08	0.22	3.78	7.31	88.61
S 70	0.53	0.02	0.07	0.19	0.93	1.41	96.85
S 71	0.00	0.00	0.00	0.05	0.45	1.85	97.66
S 72	0.00	0.00	0.02	0.04	0.57	2.93	96.44
S 73	0.00	0.00	0.00	0.05	0.27	2.04	97.64
S 74	0.03	0.00	0.00	0.09	0.06	0.26	99.57

Physalia

Table E1b. Sediment particle size fractions in the *KS Endeavor* near- and far-field survey areas. Values presented as % dry weight of each particle size fraction.

Granulometric Characteristics of Sediment Samples: *KS Endeavor* Residual Impact Assessment Full Survey Area

January - February 2016

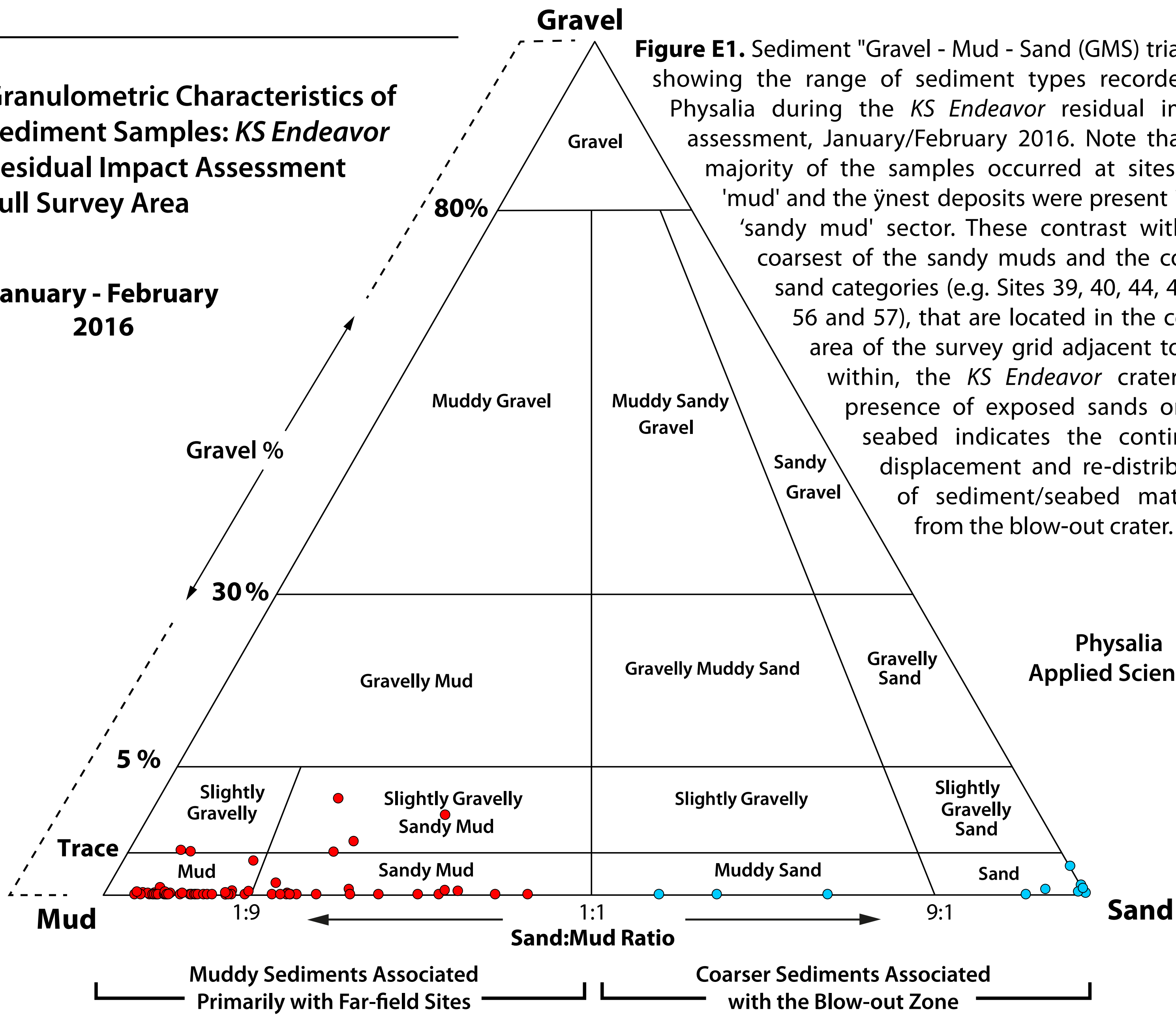


Figure E1. Sediment "Gravel - Mud - Sand (GMS) triangle" showing the range of sediment types recorded by Physalia during the *KS Endeavor* residual impact assessment, January/February 2016. Note that the majority of the samples occurred at sites with 'mud' and the ÿnest deposits were present in the 'sandy mud' sector. These contrast with the coarsest of the sandy muds and the coarser sand categories (e.g. Sites 39, 40, 44, 45, 47, 56 and 57), that are located in the central area of the survey grid adjacent to, and within, the *KS Endeavor* crater. The presence of exposed sands on the seabed indicates the continuing displacement and re-distribution of sediment/seabed materials from the blow-out crater.

Physalia Applied Sciences

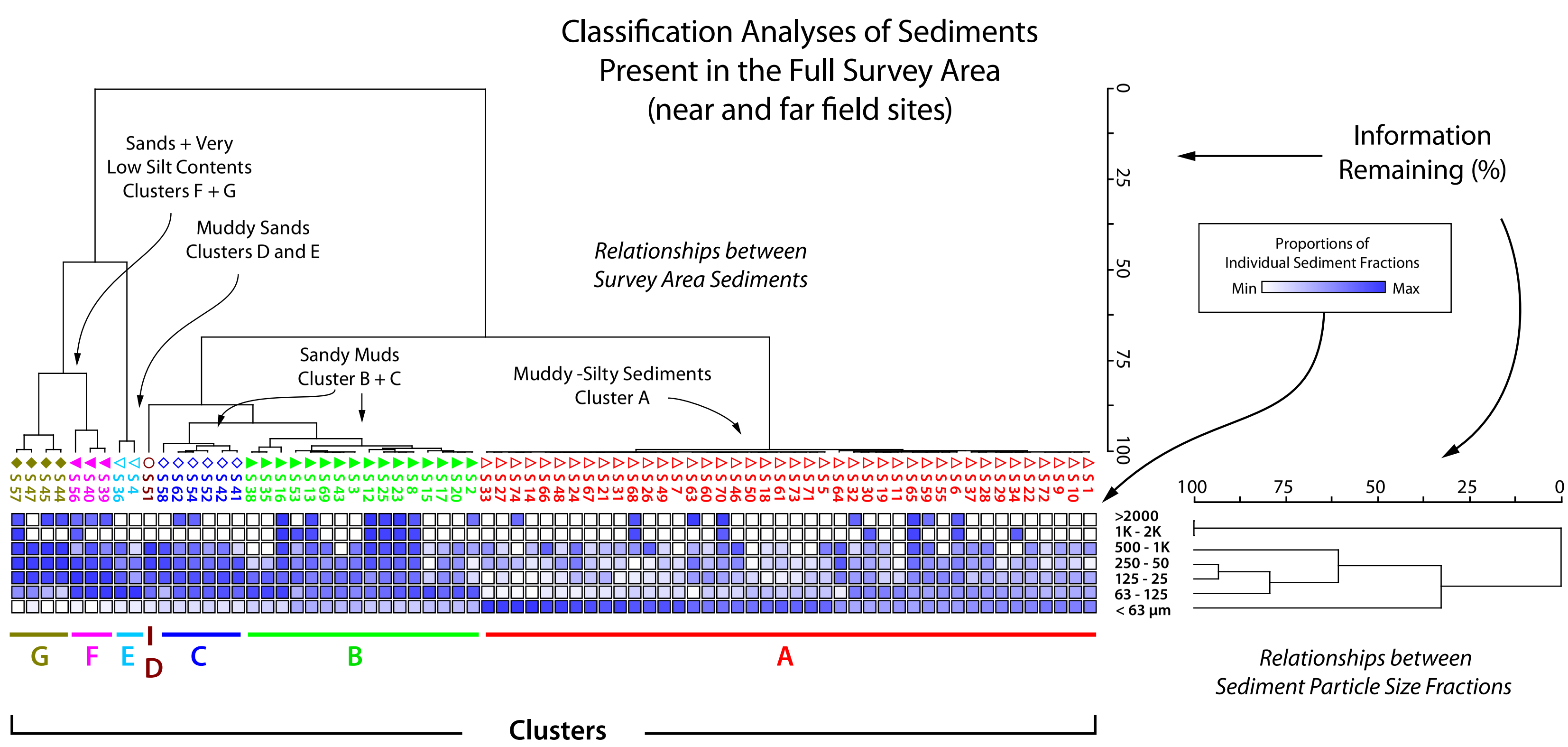


Figure E2. Two-way ordination analyses based solely on the proportions of sediment paricle size fractions. Clusters G, F, D and C included most of the coarser sediments whilst Clusters A and B included most of the sampling sites present in the shallower far-field sediments that surrounded the blow-out zone and its crater. Note the reduced proportions of the < 63 µm (silt) particles in Clusters D to G.

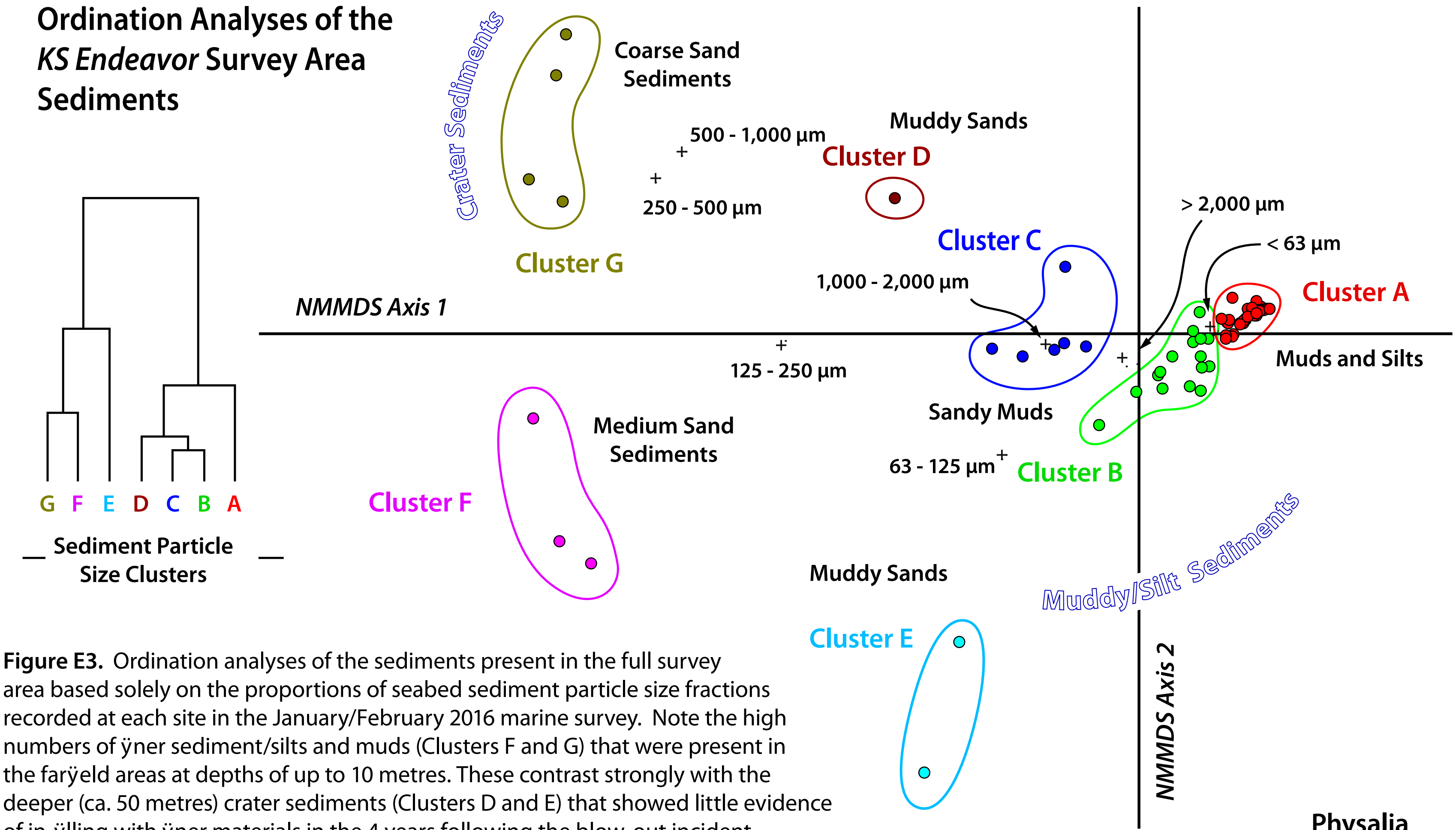


Figure E3. Ordination analyses of the sediments present in the full survey area based solely on the proportions of seabed sediment particle size fractions recorded at each site in the January/February 2016 marine survey. Note the high numbers of ÿner sediment/silts and muds (Clusters F and G) that were present in the farÿeld areas at depths of up to 10 metres. These contrast strongly with the deeper (ca. 50 metres) crater sediments (Clusters D and E) that showed little evidence of in-ÿlling with ÿner materials in the 4 years following the blow-out incident.

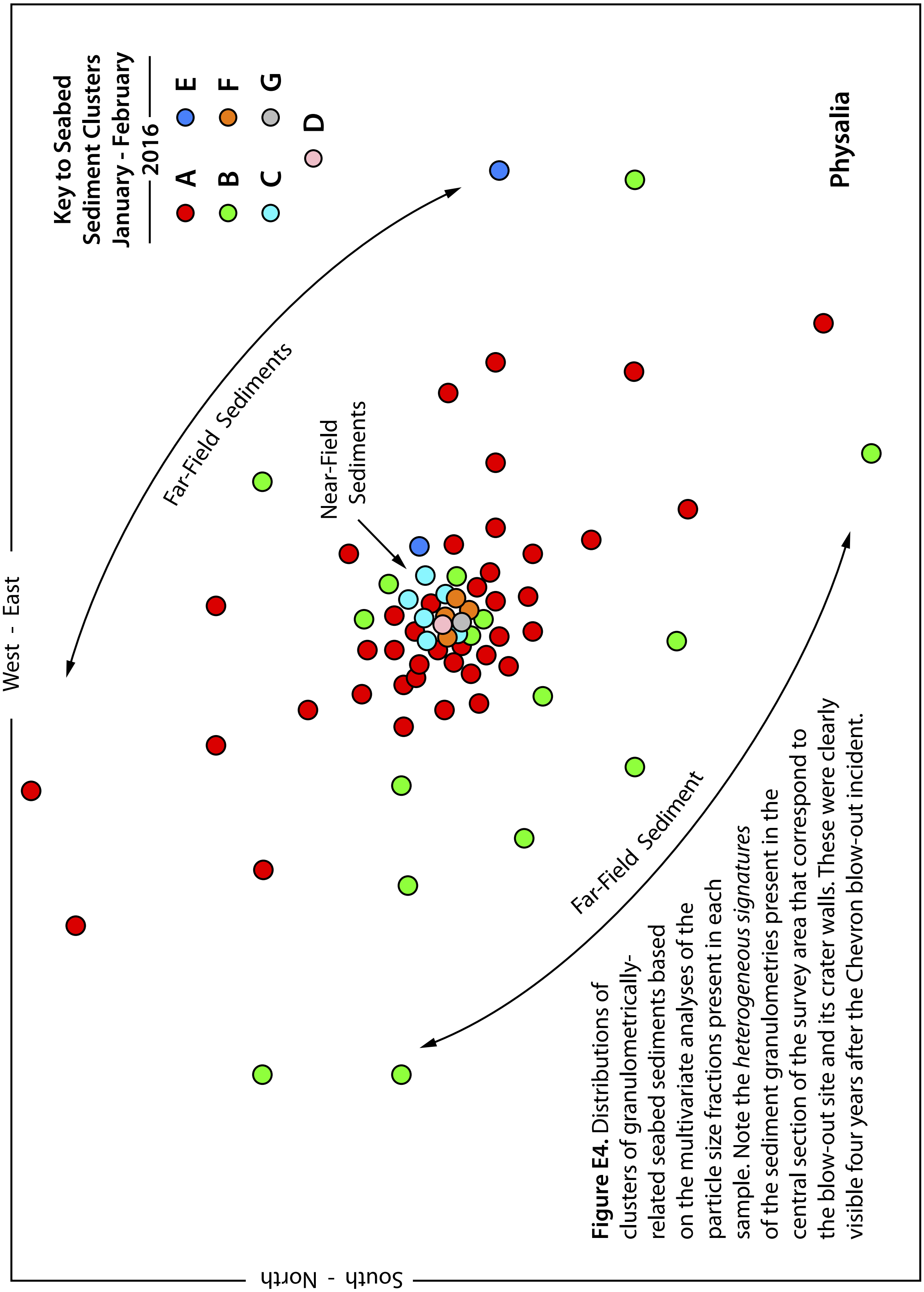
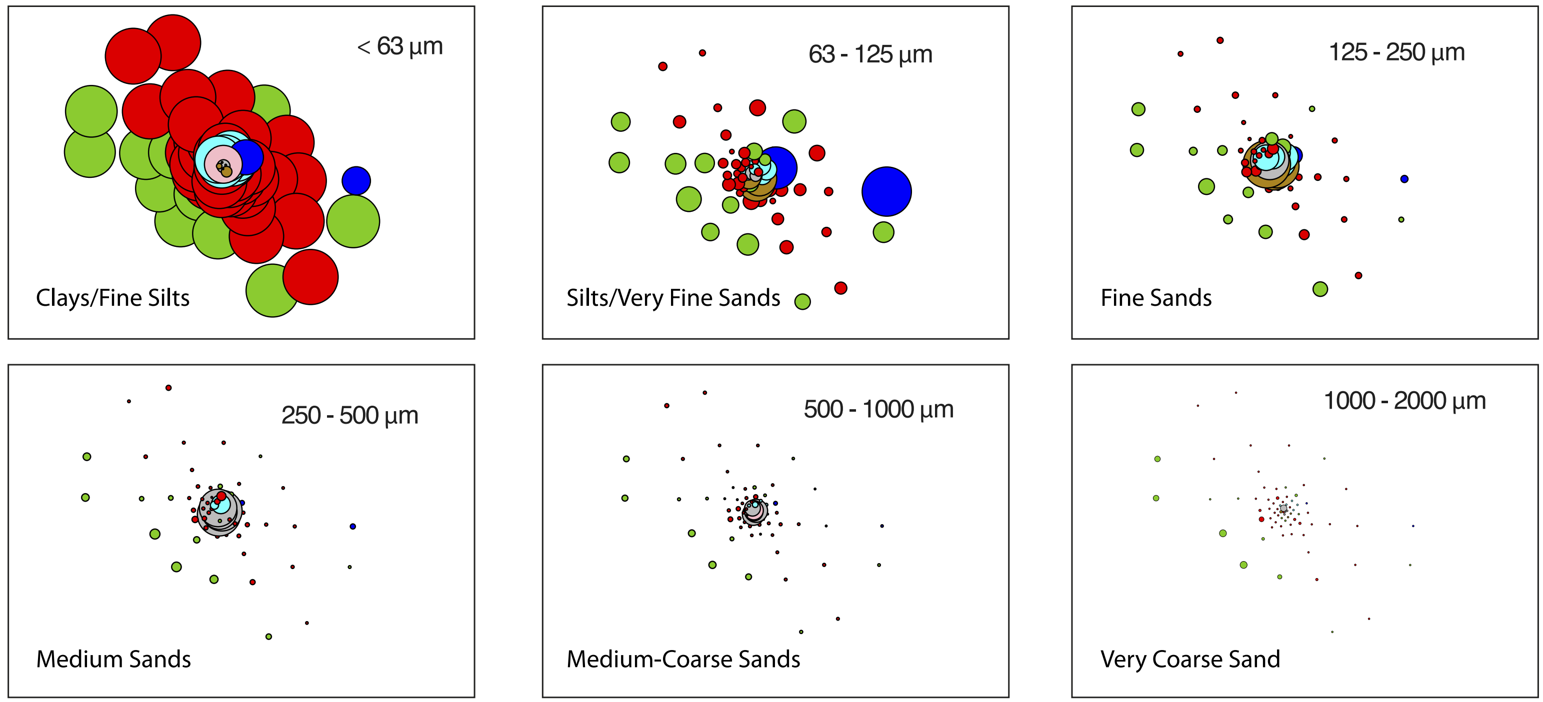


Figure E4. Distributions of clusters of granulometrically-related seabed sediments based on the multivariate analyses of the particle size fractions present in each sample. Note the *heterogeneous signatures* of the sediment granulometries present in the central section of the survey area that correspond to the blow-out site and its crater walls. These were clearly visible four years after the Chevron blow-out incident.



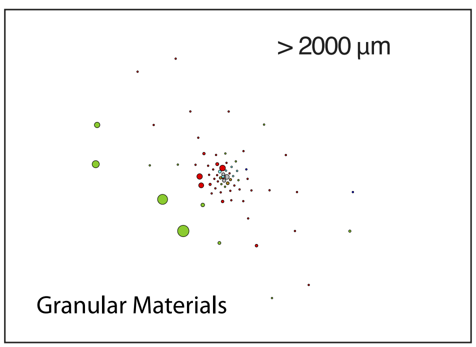
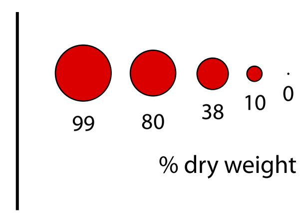


Figure E5. Sediment particle (grain) size frequencies recorded in the January - February 2016 survey of the sediments in the *KS Endeavor* near- and far-field survey areas. Circle colours relate to the mathematical clusters of similar sediment types that were identified by the multivariate analyses of the particle size distributions. Note the persistence of coarser sediment fractions (> 250 µm) in the central areas associated with the deeper blow-out site and the crater of ejected materials



Physalia

Physalia

Granulometric Analyses of Sediments within the Full Survey Area, January/February 2016

Table E2a

Group	Sub	Parameter	S 1	S 2	S 3	S 4	S 5
1		ANALYSIS + DATE	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016
		SIEVING ERROR:	N/A	N/A	N/A	N/A	N/A
		SAMPLE TYPE:	Unimodal, Very Well Sorted	Unimodal, Well Sorted	Unimodal, Moderately Well Sorted	Unimodal, Moderately Well Sorted	Unimodal, Very Well Sorted
		TEXTURAL GROUP:	Mud	Slightly Gravelly Sandy Mud	Sandy Mud	Muddy Sand	Mud
		SEDIMENT NAME:	Very Coarse Silt	Slightly Very Fine Gravelly Very Fine Sandy Very Coarse Silt	Very Fine Sandy Very Coarse Silt	Very Coarse Silty Very Fine Sand	Very Coarse Silt
2	a	MEAN $(\bar{x}_a)$:	50.43	54.12	59.86	85.06	49.59
		SORTING (σ_a):	20.94	36.67	42.99	29.62	22.12
		SKEWNESS (Sk_a):	19.48	44.34	5.995	5.461	22.67
		KURTOSIS (K_a):	576.3	2708.6	62.61	83.33	653.9
	b	MEAN $(\bar{x}_g)$:	46.47	48.96	50.99	76.49	45.87
		SORTING (σ_g):	1.195	1.276	1.450	1.371	1.166
		SKEWNESS (Sk_g):	6.371	3.369	3.062	-0.402	9.363
		KURTOSIS (K_g):	55.00	22.85	12.07	4.904	114.1
	c	MEAN $(\bar{x}_\phi)$:	4.427	4.352	4.294	3.709	4.446
		SORTING (σ_ϕ):	0.257	0.351	0.536	0.455	0.221
		SKEWNESS (Sk_ϕ):	-6.371	-3.369	-3.062	0.402	-9.363
		KURTOSIS (K_ϕ):	55.00	22.85	12.07	4.904	114.1
3	a	MEAN (M_G):	45.57	47.06	47.04	76.32	45.27
		SORTING (σ_G):	1.242	1.338	1.418	1.450	1.237
		SKEWNESS (Sk_G):	0.000	0.171	0.259	-0.250	0.000
		KURTOSIS (K_G):	0.738	1.122	1.532	1.065	0.738
	b	MEAN (M_Z):	4.456	4.410	4.410	3.712	4.465
		SORTING (σ_I):	0.313	0.420	0.504	0.536	0.307
		SKEWNESS (Sk_I):	0.000	-0.171	-0.259	0.250	0.000
		KURTOSIS (K_G):	0.738	1.122	1.532	1.065	0.738
	c	MEAN:	Very Coarse Silt	Very Coarse Silt	Very Coarse Silt	Very Fine Sand	Very Coarse Silt
		SORTING:	Very Well Sorted	Well Sorted	Moderately Well Sorted	Moderately Well Sorted	Very Well Sorted
		SKEWNESS:	Symmetrical	Coarse Skewed	Coarse Skewed	Fine Skewed	Symmetrical
		KURTOSIS:	Platykurtic	Leptokurtic	Very Leptokurtic	Mesokurtic	Platykurtic

Notes:

1. Descriptive data outlining sediment samples analysed and the analysts' description of sediment type, textural groups (sample type classiÿcations) and the full, technical granulometric sediment name re°ec ting variations in samples, ranging from uniform to heterogeneous, surveay area deposits

2. Mathematical descriptions of sediment types based on "Methods of Moments" divided into a). arithmetic method of moments, b). geometric method of moments and c). logarithmic method of moments

3. Folk and Ward descriptive sediment granulometric method of sediment description based on a). logarithmic and b). graphical methods along with a reÿned textural description system addressing features comprising sorting, skewness and kurtosis.

Physalia

Granulometric Analyses of Sediments within the Full Survey Area, January/February 2016

Table E2b

			Sediment Samples				
			S 6	S 7	S 8	S 9	S 10
1		ANALYS + DATE	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016
		SIEVING ERROR:	N/A	N/A	N/A	N/A	N/A
		SAMPLE TYPE:	Unimodal, Well Sorted	Unimodal, Very Well Sorted	Unimodal, Moderately Well Sorted		Unimodal, Very Well Sorted
		TEXTURAL GROUP:	Slightly Gravelly Mud	Mud	Slightly Gravelly Sandy Mud	Mud	Mud
		SEDIMENT NAME:	Slightly Very Fine Gravelly Very Coarse Silt	Very Coarse Silt	Slightly Very Fine Gravelly Very Fine Sandy Very Coarse Silt	Very Coarse Silt	Very Coarse Silt
2	a	MEAN ($\bar{x}_a$):	55.32	48.78	73.20	50.60	50.48
		SORTING (σ_a):	62.34	12.24	116.1	22.08	20.35
		SKEWNESS (Sk_a):	26.93	15.42	10.97	16.93	16.80
		KURTOSIS (K_a):	935.3	319.8	162.5	440.1	461.7
	b	MEAN ($\bar{x}_g$):	48.16	45.58	54.95	46.50	46.50
		SORTING (σ_g):	1.335	1.129	1.636	1.204	1.199
		SKEWNESS (Sk_g):	5.274	9.494	3.198	6.476	6.258
		KURTOSIS (K_g):	39.23	107.5	15.43	54.57	51.09
	c	MEAN ($\bar{x}_\phi$):	4.376	4.455	4.186	4.427	4.427
		SORTING (σ_ϕ):	0.417	0.175	0.710	0.268	0.261
		SKEWNESS (Sk_ϕ):	-5.274	-9.494	-3.198	-6.476	-6.258
		KURTOSIS (K_ϕ):	39.23	107.5	15.43	54.57	51.09
3	a	MEAN (M_G):	46.05	45.17	51.28	45.55	45.57
		SORTING (σ_G):	1.307	1.235	1.522	1.242	1.242
		SKEWNESS (Sk_G):	0.155	0.000	0.366	0.000	0.000
		KURTOSIS (K_G):	1.070	0.738	1.537	0.738	0.738
	b	MEAN (M_Z):	4.441	4.468	4.286	4.456	4.456
		SORTING (σ_I):	0.386	0.305	0.606	0.312	0.312
		SKEWNESS (Sk_I):	-0.155	0.000	-0.366	0.000	0.000
		KURTOSIS (K_G):	1.070	0.738	1.537	0.738	0.738
	c	MEAN:	Very Coarse Silt	Very Coarse Silt	Very Coarse Silt	Very Coarse Silt	Very Coarse Silt
		SORTING:	Well Sorted	Very Well Sorted	Moderately Well Sorted	Very Well Sorted	Very Well Sorted
		SKEWNESS:	Coarse Skewed	Symmetrical	Very Coarse Skewed	Symmetrical	Symmetrical
		KURTOSIS:	Mesokurtic	Platykurtic	Very Leptokurtic	Platykurtic	Platykurtic

Notes:

1. Descriptive data outlining sediment samples analysed and the analysts' description of sediment type, textural groups (sample type classiÿcations) and the full, technical granulometric sediment name re°ec ting variations in samples, ranging from uniform to heterogeneous, surveay area deposits

2. Mathematical descriptions of sediment types based on "Methods of Moments" divided into a). arithmetic method of moments, b). geometric method of moments and c). logarithmic method of moments

3. Folk and Ward descriptive sediment granulometric method of sediment description based on a). logarithmic and b). graphical methods along with a reÿned textural description system addressing features comprising sorting, skewness and kurtosis.

Granulometric Analyses of Sediments within the Full Survey Area, January/February 2016

Physalia

Table E2c

			Sediment Samples				
			S 11	S 12	S 13	S 14	S 15
1		ANALYS + DATE	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016
		SIEVING ERROR:	N/A	N/A	N/A	N/A	N/A
		SAMPLE TYPE:	Unimodal, Well Sorted	Unimodal, Moderately Sorted	Unimodal, Well Sorted	Unimodal, Very Well Sorted	Unimodal, Well Sorted
		TEXTURAL GROUP:	Mud	Slightly Gravelly Sandy Mud	Slightly Gravelly Sandy Mud	Mud	Sandy Mud
		SEDIMENT NAME:	Very Coarse Silt	Slightly Very Fine Gravelly Very Fine Sandy Very Coarse Silt	Slightly Very Fine Gravelly Very Fine Sandy Very Coarse Silt	Very Coarse Silt	Very Fine Sandy Very Coarse Silt
2	a	MEAN $(\bar{x}_a)$:	50.95	161.9	61.30	48.02	55.30
		SORTING (σ_a):	14.51	450.6	101.5	13.17	21.15
		SKEWNESS (Sk_a):	6.659	4.410	18.44	39.15	8.546
		KURTOSIS (K_a):	81.78	21.34	401.3	1840.7	217.9
	b	MEAN $(\bar{x}_g)$:	47.10	61.69	49.94	45.08	50.12
		SORTING (σ_g):	1.202	2.428	1.443	1.083	1.298
		SKEWNESS (Sk_g):	4.024	3.166	4.782	22.99	2.230
		KURTOSIS (K_g):	20.46	12.19	33.25	600.3	8.026
	c	MEAN $(\bar{x}_\phi)$:	4.408	4.019	4.324	4.471	4.319
		SORTING (σ_ϕ):	0.266	1.280	0.529	0.115	0.376
		SKEWNESS (Sk_ϕ):	-4.024	-3.166	-4.782	-22.989	-2.230
		KURTOSIS (K_ϕ):	20.46	12.19	33.25	600.3	8.026
3	a	MEAN (M_G):	45.99	49.65	46.71	44.95	47.81
		SORTING (σ_G):	1.281	1.855	1.359	1.231	1.358
		SKEWNESS (Sk_G):	0.102	0.448	0.210	0.000	0.176
		KURTOSIS (K_G):	0.926	3.017	1.272	0.738	1.139
	b	MEAN (M_Z):	4.442	4.332	4.420	4.476	4.386
		SORTING (σ_I):	0.357	0.891	0.442	0.300	0.441
		SKEWNESS (Sk_I):	-0.102	-0.448	-0.210	0.000	-0.176
		KURTOSIS (K_G):	0.926	3.017	1.272	0.738	1.139
	c	MEAN:	Very Coarse Silt	Very Coarse Silt	Very Coarse Silt	Very Coarse Silt	Very Coarse Silt
		SORTING:	Well Sorted	Moderately Sorted	Well Sorted	Very Well Sorted	Well Sorted
		SKEWNESS:	Coarse Skewed	Very Coarse Skewed	Coarse Skewed	Symmetrical	Coarse Skewed
		KURTOSIS:	Mesokurtic	Extremely Leptokurtic	Leptokurtic	Platykurtic	Leptokurtic

Notes:

1. Descriptive data outlining sediment samples analysed and the analysts' description of sediment type, textural groups (sample type classiÿcations) and the full, technical granulometric sediment name re°ec ting variations in samples, ranging from uniform to heterogeneous, surveay area deposits

2. Mathematical descriptions of sediment types based on "Methods of Moments" divided into a). arithmetic method of moments, b). geometric method of moments and c). logarithmic method of moments

3. Folk and Ward descriptive sediment granulometric method of sediment description based on a). logarithmic and b). graphical methods along with a reÿned textural description system addressing features comprising sorting, skewness and kurtosis.

Granulometric Analyses of Sediments within the Full Survey Area, January/February 2016

Physalia

Table E2d

			Sediment Samples				
			S 16	S 17	S 18	S 19	S 20
1		ANALYS + DATE	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016
		SIEVING ERROR:	N/A	N/A	N/A	N/A	N/A
		SAMPLE TYPE:	Unimodal, Moderately Sorted	Unimodal, Well Sorted	Unimodal, Very Well Sorted	Unimodal, Well Sorted	Unimodal, Well Sorted
		TEXTURAL GROUP:	Slightly Gravelly Sandy Mud	Sandy Mud	Mud	Mud	Sandy Mud
		SEDIMENT NAME:	Slightly Very Fine Gravelly Very Fine Sandy Very Coarse Silt	Very Fine Sandy Very Coarse Silt	Very Coarse Silt	Very Coarse Silt	Very Fine Sandy Very Coarse Silt
2	a	MEAN $(\bar{x}_a)$:	151.9	56.16	49.07	51.40	55.83
		SORTING (σ_a):	395.9	31.05	14.63	19.46	30.51
		SKEWNESS (Sk_a):	4.976	7.694	24.99	15.52	10.04
		KURTOSIS (K_a):	27.27	106.1	949.3	440.1	174.1
	b	MEAN $(\bar{x}_g)$:	68.01	49.81	45.77	47.26	49.79
		SORTING (σ_g):	2.322	1.346	1.138	1.218	1.329
		SKEWNESS (Sk_g):	2.719	3.245	8.570	4.473	3.206
		KURTOSIS (K_g):	10.58	14.99	101.4	29.31	15.97
	c	MEAN $(\bar{x}_\phi)$:	3.878	4.327	4.449	4.403	4.328
		SORTING (σ_ϕ):	1.215	0.428	0.186	0.284	0.410
		SKEWNESS (Sk_ϕ):	-2.719	-3.245	-8.570	-4.473	-3.206
		KURTOSIS (K_ϕ):	10.58	14.99	101.4	29.31	15.97
3	a	MEAN (M_G):	60.31	47.14	45.29	46.05	47.30
		SORTING (σ_G):	1.928	1.357	1.237	1.287	1.354
		SKEWNESS (Sk_G):	0.522	0.195	0.000	0.113	0.186
		KURTOSIS (K_G):	1.566	1.210	0.738	0.954	1.176
	b	MEAN (M_Z):	4.051	4.407	4.465	4.441	4.402
		SORTING (σ_I):	0.947	0.440	0.307	0.364	0.437
		SKEWNESS (Sk_I):	-0.522	-0.195	0.000	-0.113	-0.186
		KURTOSIS (K_G):	1.566	1.210	0.738	0.954	1.176
	c	MEAN:	Very Coarse Silt	Very Coarse Silt	Very Coarse Silt	Very Coarse Silt	Very Coarse Silt
		SORTING:	Moderately Sorted	Well Sorted	Very Well Sorted	Well Sorted	Well Sorted
		SKEWNESS:	Very Coarse Skewed	Coarse Skewed	Symmetrical	Coarse Skewed	Coarse Skewed
		KURTOSIS:	Very Leptokurtic	Leptokurtic	Platykurtic	Mesokurtic	Leptokurtic

Notes:

1. Descriptive data outlining sediment samples analysed and the analysts' description of sediment type, textural groups (sample type classiÿcations) and the full, technical granulometric sediment name re°ec ting variations in samples, ranging from uniform to heterogeneous, surveay area deposits

2. Mathematical descriptions of sediment types based on "Methods of Moments" divided into a). arithmetic method of moments, b). geometric method of moments and c). logarithmic method of moments

3. Folk and Ward descriptive sediment granulometric method of sediment description based on a). logarithmic and b). graphical methods along with a reÿned textural description system addressing features comprising sorting, skewness and kurtosis.

Physalia

Granulometric Analyses of Sediments within the Full Survey Area, January/February 2016

Table E2e

			Sediment Samples				
			S 21	S 22	S 23	S 24	S 25
1		ANALYS + DATE	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016
		SIEVING ERROR:	N/A	N/A	N/A	N/A	N/A
		SAMPLE TYPE:	Unimodal, Very Well Sorted	Unimodal, Very Well Sorted	Unimodal, Moderately Well Sorted	Unimodal, Very Well Sorted	Unimodal, Moderately Well Sorted
		TEXTURAL GROUP:	Mud	Mud	Slightly Gravelly Sandy Mud	Mud	Slightly Gravelly Sandy Mud
		SEDIMENT NAME:	Very Coarse Silt	Very Coarse Silt		Very Coarse Silt	Slightly Very Fine Gravelly Very Fine Sandy Very Coarse Silt
2	a	MEAN $(\bar{x}_a)$:	49.24	50.69	100.6	50.27	85.71
		SORTING (σ_a):	17.32	22.93	272.8	29.24	209.9
		SKEWNESS (Sk_a)	20.36	17.82	7.316	15.27	8.867
		KURTOSIS (K_a):	647.0	461.0	58.49	290.7	88.70
	b	MEAN $(\bar{x}_g)$:	45.73	46.57	57.01	45.88	54.87
		SORTING (σ_g):	1.155	1.205	1.897	1.203	1.762
		SKEWNESS (Sk_g)	9.239	6.453	3.735	9.749	3.887
		KURTOSIS (K_g):	101.4	56.39	18.77	105.9	20.68
	c	MEAN $(\bar{x}_\phi)$:	4.451	4.425	4.133	4.446	4.188
		SORTING (σ_ϕ):	0.208	0.269	0.924	0.266	0.817
		SKEWNESS (Sk_ϕ)	-9.239	-6.453	-3.735	-9.749	-3.887
		KURTOSIS (K_ϕ):	101.4	56.39	18.77	105.9	20.68
3	a	MEAN (M_G):	45.19	45.61	51.23	45.15	48.49
		SORTING (σ_G):	1.235	1.242	1.563	1.235	1.483
		SKEWNESS (Sk_G)	0.000	0.000	0.393	0.000	0.303
		KURTOSIS (K_G):	0.738	0.738	1.717	0.738	1.657
	b	MEAN (M_Z):	4.468	4.455	4.287	4.469	4.366
		SORTING (σ_I):	0.305	0.313	0.645	0.304	0.568
		SKEWNESS (Sk_I)	0.000	0.000	-0.393	0.000	-0.303
		KURTOSIS (K_G):	0.738	0.738	1.717	0.738	1.657
	c	MEAN:	Very Coarse Silt	Very Coarse Silt	Very Coarse Silt	Very Coarse Silt	Very Coarse Silt
		SORTING:	Very Well Sorted	Very Well Sorted	Moderately Well Sorted	Very Well Sorted	Moderately Well Sorted
		SKEWNESS:	Symmetrical	Symmetrical	Very Coarse Skewed	Symmetrical	Very Coarse Skewed
		KURTOSIS:	Platykurtic	Platykurtic	Very Leptokurtic	Platykurtic	Very Leptokurtic

Notes:

1. Descriptive data outlining sediment samples analysed and the analysts' description of sediment type, textural groups (sample type classiÿcations) and the full, technical granulometric sediment name re°ec ting variations in samples, ranging from uniform to heterogeneous, surveay area deposits

2. Mathematical descriptions of sediment types based on "Methods of Moments" divided into a). arithmetic method of moments, b). geometric method of moments and c). logarithmic method of moments

3. Folk and Ward descriptive sediment granulometric method of sediment description based on a). logarithmic and b). graphical methods along with a reÿned textural description system addressing features comprising sorting, skewness and kurtosis.

Granulometric Analyses of Sediments within the Full Survey Area, January/February 2016

Physalia

Table E2f

			Sediment Samples					
			S 26	S 27	S 28	S 29	S 30	S 31
1		ANALYS + DATE	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016
		SIEVING ERROR:	N/A	N/A	N/A	N/A	N/A	N/A
		SAMPLE TYPE:	Unimodal, Very Well Sorted	Unimodal, Very Well Sorted	Unimodal, Very Well Sorted	Unimodal, Very Well Sorted	Unimodal, Well Sorted	Unimodal, Very Well Sorted
		TEXTURAL GROUP:	Mud	Mud	Mud	Mud	Mud	Mud
		SEDIMENT NAME:	Very Coarse Silt	Very Coarse Silt	Very Coarse Silt	Very Coarse Silt	Very Coarse Silt	Very Coarse Silt
2	a	MEAN $(\bar{x}_a)$:	49.98	48.71	51.38	50.25	53.20	48.71
		SORTING (σ_a):	32.55	17.79	26.54	15.00	32.68	15.96
		SKEWNESS (Sk_a):	19.67	23.65	15.61	9.021	22.05	29.55
		KURTOSIS (K_a):	415.3	726.5	340.9	126.9	810.5	1137.0
	b	MEAN $(\bar{x}_g)$:	45.77	45.37	46.86	46.53	47.94	45.49
		SORTING (σ_g):	1.179	1.129	1.228	1.186	1.277	1.123
		SKEWNESS (Sk_g):	11.81	13.65	6.172	5.355	4.622	11.89
		KURTOSIS (K_g):	169.6	212.7	51.23	35.75	30.98	186.7
	c	MEAN $(\bar{x}_\phi)$:	4.450	4.462	4.416	4.426	4.383	4.458
		SORTING (σ_ϕ):	0.238	0.175	0.297	0.246	0.352	0.167
		SKEWNESS (Sk_ϕ):	-11.812	-13.655	-6.172	-5.355	-4.622	-11.890
		KURTOSIS (K_ϕ):	169.6	212.7	51.23	35.75	30.98	186.7
3	a	MEAN (M_G):	45.19	45.04	45.71	45.65	46.22	45.14
		SORTING (σ_G):	1.236	1.233	1.246	1.243	1.308	1.235
		SKEWNESS (Sk_G):	0.000	0.000	0.005	0.000	0.151	0.000
		KURTOSIS (K_G):	0.738	0.738	0.745	0.738	1.056	0.738
	b	MEAN (M_Z):	4.468	4.473	4.451	4.453	4.435	4.469
		SORTING (σ_I):	0.305	0.302	0.317	0.314	0.388	0.304
		SKEWNESS (Sk_I):	0.000	0.000	-0.005	0.000	-0.151	0.000
		KURTOSIS (K_G):	0.738	0.738	0.745	0.738	1.056	0.738
	c	MEAN:	Very Coarse Silt	Very Coarse Silt	Very Coarse Silt	Very Coarse Silt	Very Coarse Silt	Very Coarse Silt
		SORTING:	Very Well Sorted	Very Well Sorted	Very Well Sorted	Very Well Sorted	Well Sorted	Very Well Sorted
		SKEWNESS:	Symmetrical	Symmetrical	Symmetrical	Symmetrical	Coarse Skewed	Symmetrical
		KURTOSIS:	Platykurtic	Platykurtic	Platykurtic	Platykurtic	Mesokurtic	Platykurtic

Notes:

1. Descriptive data outlining sediment samples analysed and the analysts' description of sediment type, textural groups (sample type classiÿcations) and the full, technical granulometric sediment name re°ec ting variations in samples, ranging from uniform to heterogeneous, surveay area deposits

2. Mathematical descriptions of sediment types based on "Methods of Moments" divided into a). arithmetic method of moments, b). geometric method of moments and c). logarithmic method of moments

3. Folk and Ward descriptive sediment granulometric method of sediment description based on a). logarithmic and b). graphical methods along with a reÿned textural description system addressing features comprising sorting, skewness and kurtosis.

Physalia

Granulometric Analyses of Sediments within the Full Survey Area, January/February 2016

Table E2g

			Sediment Samples				
			S 32	S 33	S 34	S 35	S 36
1		ANALYS + DATE	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016
1		SIEVING ERROR:	N/A	N/A	N/A	N/A	N/A
1		SAMPLE TYPE:	Unimodal, Well Sorted	Unimodal, Very Well Sorted	Unimodal, Very Well Sorted	Unimodal, Moderately Well Sorted	Unimodal, Moderately Well Sorted
1		TEXTURAL GROUP:	Slightly Gravelly Mud	Mud	Mud	Sandy Mud	Muddy Sand
1		SEDIMENT NAME:	Slightly Very Fine Gravelly Very Coarse Silt	Very Coarse Silt	Very Coarse Silt	Very Fine Sandy Very Coarse Silt	Very Coarse Silty Very Fine Sand
2	a	MEAN $(\bar{x}_a)$:	53.54	48.54	50.68	65.65	86.02
2	a	SORTING (σ_a):	50.37	19.90	26.15	40.01	48.37
2	a	SKEWNESS (Sk_a)	37.53	28.13	34.37	2.554	5.181
2	a	KURTOSIS (K_a):	1709.3	896.0	1774.9	9.776	60.29
2	b	MEAN $(\bar{x}_g)$:	47.95	45.26	46.57	55.46	73.31
2	b	SORTING (σ_g):	1.276	1.115	1.202	1.518	1.540
2	b	SKEWNESS (Sk_g)	5.083	17.77	6.397	1.839	0.547
2	b	KURTOSIS (K_g):	43.22	365.7	58.38	5.197	3.714
2	c	MEAN $(\bar{x}_\phi)$:	4.382	4.466	4.424	4.172	3.770
2	c	SORTING (σ_ϕ):	0.352	0.158	0.266	0.602	0.623
2	c	SKEWNESS (Sk_ϕ)	-5.083	-17.772	-6.397	-1.839	-0.547
2	c	KURTOSIS (K_ϕ):	43.22	365.7	58.38	5.197	3.714
3	a	MEAN (M_G):	46.26	45.01	45.62	54.09	71.15
3	a	SORTING (σ_G):	1.309	1.233	1.243	1.570	1.619
3	a	SKEWNESS (Sk_G)	0.151	0.000	0.000	0.397	-0.037
3	a	KURTOSIS (K_G):	1.055	0.738	0.738	1.461	0.921
3	b	MEAN (M_Z):	4.434	4.473	4.454	4.209	3.813
3	b	SORTING (σ_I):	0.388	0.302	0.313	0.650	0.695
3	b	SKEWNESS (Sk_I)	-0.151	0.000	0.000	-0.397	0.037
3	b	KURTOSIS (K_G):	1.055	0.738	0.738	1.461	0.921
3	c	MEAN:	Very Coarse Silt	Very Coarse Silt	Very Coarse Silt	Very Coarse Silt	Very Fine Sand
3	c	SORTING:	Well Sorted	Very Well Sorted	Very Well Sorted	Moderately Well Sorted	Moderately Well Sorted
3	c	SKEWNESS:	Coarse Skewed	Symmetrical	Symmetrical	Very Coarse Skewed	Symmetrical
3	c	KURTOSIS:	Mesokurtic	Platykurtic	Platykurtic	Leptokurtic	Mesokurtic

Notes:

1. Descriptive data outlining sediment samples analysed and the analysts' description of sediment type, textural groups (sample type classiÿcations) and the full, technical granulometric sediment name re°ec ting variations in samples, ranging from uniform to heterogeneous, surveay area deposits

2. Mathematical descriptions of sediment types based on "Methods of Moments" divided into a). arithmetic method of moments, b). geometric method of moments and c). logarithmic method of moments

3. Folk and Ward descriptive sediment granulometric method of sediment description based on a). logarithmic and b). graphical methods along with a reÿned textural description system addressing features comprising sorting, skewness and kurtosis.

Physalia

Granulometric Analyses of Sediments within the Full Survey Area, January/February 2016

Table E2h

			Sediment Samples				
			S 37	**S 38**	**S 39**	**S 40**	**S 41**
1		ANALYS + DATE	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016
		SIEVING ERROR:	N/A	N/A	N/A	N/A	N/A
		SAMPLE TYPE:		Unimodal, Moderately Well Sorted	Unimodal, Moderately Well Sorted	Unimodal, Moderately Well Sorted	Bimodal, Moderately Sorted
		TEXTURAL GROUP:	Mud	Sandy Mud	Slightly Gravelly Sand	Slightly Gravelly Sand	Sandy Mud
		SEDIMENT NAME:	Very Coarse Silt	Very Fine Sandy Very Coarse Silt	Slightly Very Fine Gravelly Fine Sand	Slightly Very Fine Gravelly Fine Sand	Fine Sandy Very Coarse Silt
2	a	MEAN $(\bar{x}_a)$:	51.12	61.12	154.3	165.8	98.49
		SORTING (σ_a):	24.83	33.23	89.37	81.22	72.64
		SKEWNESS (Sk_a):	16.74	3.115	10.33	5.947	1.447
		KURTOSIS (K_a):	393.2	14.44	244.0	117.9	5.676
	b	MEAN $(\bar{x}_g)$:	46.80	53.04	131.4	143.7	74.10
		SORTING (σ_g):	1.217	1.436	1.553	1.492	1.903
		SKEWNESS (Sk_g):	6.165	2.135	0.206	0.337	0.699
		KURTOSIS (K_g):	52.80	6.738	3.786	3.536	1.835
	c	MEAN $(\bar{x}_\phi)$:	4.417	4.237	2.928	2.799	3.754
		SORTING (σ_ϕ):	0.283	0.522	0.635	0.577	0.928
		SKEWNESS (Sk_ϕ):	-6.165	-2.135	-0.206	-0.337	-0.699
		KURTOSIS (K_ϕ):	52.80	6.738	3.786	3.536	1.835
3	a	MEAN (M_G):	45.73	51.06	130.5	140.6	72.86
		SORTING (σ_G):	1.247	1.455	1.577	1.549	1.962
		SKEWNESS (Sk_G):	0.012	0.305	-0.060	-0.147	0.478
		KURTOSIS (K_G):	0.756	1.269	0.742	0.812	0.652
	b	MEAN (M_Z):	4.451	4.292	2.938	2.830	3.779
		SORTING (σ_I):	0.319	0.541	0.657	0.631	0.972
		SKEWNESS (Sk_I):	-0.012	-0.305	0.060	0.147	-0.478
		KURTOSIS (K_G):	0.756	1.269	0.742	0.812	0.652
	c	MEAN:	Very Coarse Silt	Very Coarse Silt	Fine Sand	Fine Sand	Very Fine Sand
		SORTING:	Very Well Sorted	Moderately Well Sorted	Moderately Well Sorted	Moderately Well Sorted	Moderately Sorted
		SKEWNESS:	Symmetrical	Very Coarse Skewed	Symmetrical	Fine Skewed	Very Coarse Skewed
		KURTOSIS:	Platykurtic	Leptokurtic	Platykurtic	Platykurtic	Very Platykurtic

Notes:

1. Descriptive data outlining sediment samples analysed and the analysts' description of sediment type, textural groups (sample type classiÿcations) and the full, technical granulometric sediment name re°ec ting variations in samples, ranging from uniform to heterogeneous, surveay area deposits

2. Mathematical descriptions of sediment types based on "Methods of Moments" divided into a). arithmetic method of moments, b). geometric method of moments and c). logarithmic method of moments

3. Folk and Ward descriptive sediment granulometric method of sediment description based on a). logarithmic and b). graphical methods along with a reÿned textural description system addressing features comprising sorting, skewness and kurtosis.

Physalia

Granulometric Analyses of Sediments within the Full Survey Area, January/February 2016

Table E2i

			Sediment Samples				
			S 42	**S 43**	**S 44**	**S 45**	**S 46**
1		ANALYS + DATE	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016
		SIEVING ERROR:	N/A	N/A	N/A	N/A	N/A
		SAMPLE TYPE:	Bimodal, Moderately Sorted	Unimodal, Well Sorted	Unimodal, Moderately Sorted	Unimodal, Moderately Sorted	Unimodal, Very Well Sorted
		TEXTURAL GROUP:	Sandy Mud	Sandy Mud	Slightly Gravelly Sand	Slightly Gravelly Sand	Mud
		SEDIMENT NAME:	Fine Sandy Very Coarse Silt	Very Fine Sandy Very Coarse Silt	Slightly Very Fine Gravelly Medium Sand		Very Coarse Silt
2	a	MEAN $(\bar{x}_a)$:	90.49	58.33	377.9	380.1	51.72
		SORTING (σ_a):	68.14	35.67	188.9	223.2	41.87
		SKEWNESS (Sk_a):	1.993	4.538	2.142	2.989	14.06
		KURTOSIS (K_a):	10.47	29.09	17.01	24.01	220.6
	b	MEAN $(\bar{x}_g)$:	69.15	50.61	319.1	312.0	46.28
		SORTING (σ_g):	1.834	1.410	1.603	1.690	1.245
		SKEWNESS (Sk_g):	0.924	3.021	-0.057	0.041	8.996
		KURTOSIS (K_g):	2.286	11.73	3.095	3.119	93.66
	c	MEAN $(\bar{x}_\phi)$:	3.854	4.304	1.648	1.680	4.434
		SORTING (σ_ϕ):	0.875	0.496	0.680	0.757	0.316
		SKEWNESS (Sk_ϕ):	-0.924	-3.021	0.057	-0.041	-8.996
		KURTOSIS (K_ϕ):	2.286	11.73	3.095	3.119	93.66
3	a	MEAN (M_G):	69.59	47.13	308.1	303.6	45.29
		SORTING (σ_G):	1.914	1.388	1.674	1.748	1.237
		SKEWNESS (Sk_G):	0.493	0.231	-0.081	-0.042	0.000
		KURTOSIS (K_G):	0.717	1.371	1.110	0.992	0.738
	b	MEAN (M_Z):	3.845	4.407	1.699	1.720	4.465
		SORTING (σ_I):	0.937	0.473	0.744	0.806	0.307
		SKEWNESS (Sk_I):	-0.493	-0.231	0.081	0.042	0.000
		KURTOSIS (K_G):	0.717	1.371	1.110	0.992	0.738
	c	MEAN:	Very Fine Sand	Very Coarse Silt	Medium Sand	Medium Sand	Very Coarse Silt
		SORTING:	Moderately Sorted	Well Sorted	Moderately Sorted	Moderately Sorted	Very Well Sorted
		SKEWNESS:	Very Coarse Skewed	Coarse Skewed	Symmetrical	Symmetrical	Symmetrical
		KURTOSIS:	Platykurtic	Leptokurtic	Leptokurtic	Mesokurtic	Platykurtic

Notes:

1. Descriptive data outlining sediment samples analysed and the analysts' description of sediment type, textural groups (sample type classiÿcations) and the full, technical granulometric sediment name re°ec ting variations in samples, ranging from uniform to heterogeneous, surveay area deposits

2. Mathematical descriptions of sediment types based on "Methods of Moments" divided into a). arithmetic method of moments, b). geometric method of moments and c). logarithmic method of moments

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Granulometric Analyses of Sediments within the Full Survey Area, January/February 2016

Physalia

Table E2j

			Sediment Samples					
			S 47	**S 48**	**S 49**	**S 50**	**S 51**	**S 52**
1		ANALYS + DATE	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016
		SIEVING ERROR:	N/A	N/A	N/A	N/A	N/A	N/A
		SAMPLE TYPE:	Unimodal, Moderately Sorted	Unimodal, Very Well Sorted	Unimodal, Very Well Sorted	Unimodal, Very Well Sorted	Bimodal, Poorly Sorted	Bimodal, Moderately Sorted
		TEXTURAL GROUP:	Sand	Mud	Mud	Mud	Muddy Sand	Sandy Mud
		SEDIMENT NAME:	Moderately Sorted Fine Sand	Very Coarse Silt	Very Coarse Silt	Very Coarse Silt	Very Coarse Silty Medium Sand	Fine Sandy Very Coarse Silt
2	a	MEAN ($\bar{x}_a$):	299.4	49.01	48.96	49.12	221.8	77.38
		SORTING (σ_a):	179.5	19.21	16.74	11.54	225.1	57.72
		SKEWNESS (Sk_a):	1.236	20.92	24.63	11.46	1.267	2.449
		KURTOSIS (K_a):	4.155	568.9	845.1	199.7	3.538	13.51
	b	MEAN ($\bar{x}_g$):	236.4	45.53	45.60	45.85	124.3	61.15
		SORTING (σ_g):	1.861	1.144	1.138	1.141	2.796	1.708
		SKEWNESS (Sk_g):	-0.457	11.92	10.55	7.125	0.340	1.402
		KURTOSIS (K_g):	3.544	166.1	140.8	61.28	1.558	3.458
	c	MEAN ($\bar{x}_\phi$):	2.081	4.457	4.455	4.447	3.008	4.031
		SORTING (σ_ϕ):	0.896	0.194	0.186	0.191	1.483	0.772
		SKEWNESS (Sk_ϕ):	0.457	-11.915	-10.551	-7.125	-0.340	-1.402
		KURTOSIS (K_ϕ):	3.544	166.1	140.8	61.28	1.558	3.458
3	a	MEAN (M_G):	243.3	45.11	45.17	45.33	122.3	62.60
		SORTING (σ_G):	1.904	1.234	1.235	1.238	2.852	1.799
		SKEWNESS (Sk_G):	0.002	0.000	0.000	0.000	0.238	0.512
		KURTOSIS (K_G):	1.102	0.738	0.738	0.738	0.649	1.217
	b	MEAN (M_Z):	2.039	4.471	4.468	4.464	3.032	3.998
		SORTING (σ_I):	0.929	0.303	0.305	0.308	1.512	0.847
		SKEWNESS (Sk_I):	-0.002	0.000	0.000	0.000	-0.238	-0.512
		KURTOSIS (K_G):	1.102	0.738	0.738	0.738	0.649	1.217
	c	MEAN:	Fine Sand	Very Coarse Silt	Very Coarse Silt	Very Coarse Silt	Very Fine Sand	Very Fine Sand
		SORTING:	Moderately Sorted	Very Well Sorted	Very Well Sorted	Very Well Sorted	Poorly Sorted	Moderately Sorted
		SKEWNESS:	Symmetrical	Symmetrical	Symmetrical	Symmetrical	Coarse Skewed	Very Coarse Skewed
		KURTOSIS:	Mesokurtic	Platykurtic	Platykurtic	Platykurtic	Very Platykurtic	Leptokurtic

Notes:

1. Descriptive data outlining sediment samples analysed and the analysts' description of sediment type, textural groups (sample type classiÿcations) and the full, technical granulometric sediment name re°ec ting variations in samples, ranging from uniform to heterogeneous, surveay area deposits

2. Mathematical descriptions of sediment types based on "Methods of Moments" divided into a). arithmetic method of moments, b). geometric method of moments and c). logarithmic method of moments

3. Folk and Ward descriptive sediment granulometric method of sediment description based on a). logarithmic and b). graphical methods along with a reÿned textural description system addressing features comprising sorting, skewness and kurtosis.

Physalia

Granulometric Analyses of Sediments within the Full Survey Area, January/February 2016

Table E2k

			Sediment Samples				
			S 53	S 54	S 55	S 56	S 57
1		ANALYS + DATE	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016
		SIEVING ERROR:	N/A	N/A	N/A	N/A	N/A
		SAMPLE TYPE:	Unimodal, Moderately Well Sorted	Bimodal, Moderately Sorted	Unimodal, Well Sorted	Unimodal, Moderately Well Sorted	Unimodal, Moderately Sorted
		TEXTURAL GROUP:	Sandy Mud	Slightly Gravelly Sandy Mud	Mud	Slightly Gravelly Sand	Slightly Gravelly Sand
		SEDIMENT NAME:			Very Coarse Silt	Slightly Very Fine Gravelly Fine Sand	Slightly Very Fine Gravelly Fine Sand
2	a	MEAN $(\bar{x}_a)$:	60.26	85.82	53.05	197.1	315.9
		SORTING (σ_a):	48.01	80.42	25.36	90.20	198.2
		SKEWNESS (Sk_a):	10.14	10.46	6.329	6.127	3.184
		KURTOSIS (K_a):	234.4	266.5	54.46	125.5	21.22
	b	MEAN $(\bar{x}_g)$:	50.84	65.44	47.80	171.8	259.3
		SORTING (σ_g):	1.469	1.799	1.286	1.481	1.660
		SKEWNESS (Sk_g):	3.099	1.217	4.403	-0.021	0.408
		KURTOSIS (K_g):	12.01	3.314	23.14	4.359	3.485
	c	MEAN $(\bar{x}_\phi)$:	4.298	3.934	4.387	2.541	1.948
		SORTING (σ_ϕ):	0.555	0.847	0.363	0.567	0.732
		SKEWNESS (Sk_ϕ):	-3.099	-1.217	-4.403	0.021	-0.408
		KURTOSIS (K_ϕ):	12.01	3.314	23.14	4.359	3.485
3	a	MEAN (M_G):	46.70	66.70	46.01	171.3	255.0
		SORTING (σ_G):	1.439	1.876	1.298	1.529	1.687
		SKEWNESS (Sk_G):	0.281	0.512	0.140	-0.033	0.097
		KURTOSIS (K_G):	1.684	0.874	1.025	1.339	0.865
	b	MEAN (M_Z):	4.420	3.906	4.442	2.546	1.971
		SORTING (σ_I):	0.525	0.908	0.376	0.613	0.755
		SKEWNESS (Sk_I):	-0.281	-0.512	-0.140	0.033	-0.097
		KURTOSIS (K_G):	1.684	0.874	1.025	1.339	0.865
	c	MEAN:	Very Coarse Silt	Very Fine Sand	Very Coarse Silt	Fine Sand	Medium Sand
		SORTING:	Moderately Well Sorted	Moderately Sorted	Well Sorted	Moderately Well Sorted	Moderately Sorted
		SKEWNESS:	Coarse Skewed	Very Coarse Skewed	Coarse Skewed	Symmetrical	Symmetrical
		KURTOSIS:	Very Leptokurtic	Platykurtic	Mesokurtic	Leptokurtic	Platykurtic

Notes:

1. Descriptive data outlining sediment samples analysed and the analysts' description of sediment type, textural groups (sample type classiÿcations) and the full, technical granulometric sediment name re°ec ting variations in samples, ranging from uniform to heterogeneous, surveay area deposits

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Physalia

Granulometric Analyses of Sediments within the Full Survey Area, January/February 2016

Table E2I

			Sediment Samples				
			S 58	S 59	S 60	S 61	S 62
1		ANALYS + DATE	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016
		SIEVING ERROR:	N/A	N/A	N/A	N/A	N/A
		SAMPLE TYPE:	Bimodal, Poorly Sorted	Unimodal, Well Sorted	Unimodal, Very Well Sorted	Unimodal, Very Well Sorted	Bimodal, Moderately Sorted
		TEXTURAL GROUP:	Sandy Mud	Slightly Gravelly Mud	Mud	Mud	Slightly Gravelly Sandy Mud
		SEDIMENT NAME:	Fine Sandy Very Coarse Silt	Slightly Very Fine Gravelly Very Coarse Silt	Very Coarse Silt	Very Coarse Silt	Slightly Very Fine Gravelly Fine Sandy Very Coarse Silt
2	a	MEAN $(\bar{x}_a)$:	109.0	54.38	51.00	49.02	84.80
		SORTING (σ_a):	114.2	47.34	23.51	16.63	83.11
		SKEWNESS (Sk_a):	2.217	27.91	11.72	25.11	11.39
		KURTOSIS (K_a):	8.769	1238.0	231.7	876.3	289.3
	b	MEAN $(\bar{x}_g)$:	71.99	47.98	46.55	45.66	64.48
		SORTING (σ_g):	2.133	1.320	1.229	1.139	1.795
		SKEWNESS (Sk_g):	1.186	5.018	6.296	10.00	1.307
		KURTOSIS (K_g):	2.834	33.60	45.58	131.2	3.604
	c	MEAN $(\bar{x}_\phi)$:	3.796	4.382	4.425	4.453	3.955
		SORTING (σ_ϕ):	1.093	0.400	0.297	0.188	0.844
		SKEWNESS (Sk_ϕ):	-1.186	-5.018	-6.296	-10.002	-1.307
		KURTOSIS (K_ϕ):	2.834	33.60	45.58	131.2	3.604
3	a	MEAN (M_G):	72.90	45.97	45.44	45.21	65.93
		SORTING (σ_G):	2.182	1.299	1.240	1.236	1.869
		SKEWNESS (Sk_G):	0.620	0.143	0.000	0.000	0.521
		KURTOSIS (K_G):	0.800	1.034	0.738	0.738	0.945
	b	MEAN (M_Z):	3.778	4.443	4.460	4.467	3.923
		SORTING (σ_I):	1.126	0.377	0.310	0.306	0.902
		SKEWNESS (Sk_I):	-0.620	-0.143	0.000	0.000	-0.521
		KURTOSIS (K_G):	0.800	1.034	0.738	0.738	0.945
	c	MEAN:	Very Fine Sand	Very Coarse Silt	Very Coarse Silt	Very Coarse Silt	Very Fine Sand
		SORTING:	Poorly Sorted	Well Sorted	Very Well Sorted	Very Well Sorted	Moderately Sorted
		SKEWNESS:	Very Coarse Skewed	Coarse Skewed	Symmetrical	Symmetrical	Very Coarse Skewed
		KURTOSIS:	Platykurtic	Mesokurtic	Platykurtic	Platykurtic	Mesokurtic

Notes:

1. Descriptive data outlining sediment samples analysed and the analysts' description of sediment type, textural groups (sample type classiÿcations) and the full, technical granulometric sediment name re°ec ting variations in samples, ranging from uniform to heterogeneous, surveay area deposits

2. Mathematical descriptions of sediment types based on "Methods of Moments" divided into a). arithmetic method of moments, b). geometric method of moments and c). logarithmic method of moments

3. Folk and Ward descriptive sediment granulometric method of sediment description based on a). logarithmic and b). graphical methods along with a reÿned textural description system addressing features comprising sorting, skewness and kurtosis.

Granulometric Analyses of Sediments within the Full Survey Area, January/February 2016

Physalia

Table E2m

			Sediment Samples				
			S 63	S 64	S 65	S 66	S 67
1		ANALYS + DATE	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016
1		SIEVING ERROR:	N/A	N/A	N/A	N/A	N/A
1		SAMPLE TYPE:	Unimodal, Very Well Sorted	Unimodal, Well Sorted	Unimodal, Well Sorted		Unimodal, Very Well Sorted
1		TEXTURAL GROUP:	Slightly Gravelly Mud	Mud	Slightly Gravelly Mud	Mud	Mud
1		SEDIMENT NAME:	Slightly Very Fine Gravelly Very Coarse Silt	Very Coarse Silt		Very Coarse Silt	Very Coarse Silt
2	a	MEAN $(\bar{x}_a)$:	65.34	59.28	71.48	49.93	49.06
2	a	SORTING (σ_a):	185.2	58.59	179.1	34.75	17.08
2	a	SKEWNESS (Sk_a):	12.24	6.650	10.84	18.70	22.36
2	a	KURTOSIS (K_a):	153.9	57.69	129.4	369.0	728.4
2	b	MEAN $(\bar{x}_g)$:	47.30	49.01	49.98	45.62	45.64
2	b	SORTING (σ_g):	1.451	1.459	1.574	1.178	1.145
2	b	SKEWNESS (Sk_g):	8.482	4.470	5.624	13.21	10.10
2	b	KURTOSIS (K_g):	81.26	22.65	39.16	199.2	124.1
2	c	MEAN $(\bar{x}_\phi)$:	4.402	4.351	4.322	4.454	4.454
2	c	SORTING (σ_ϕ):	0.537	0.545	0.654	0.236	0.195
2	c	SKEWNESS (Sk_ϕ):	-8.482	-4.470	-5.624	-13.211	-10.096
2	c	KURTOSIS (K_ϕ):	81.26	22.65	39.16	199.2	124.1
3	a	MEAN (M_G):	45.29	45.82	46.22	45.11	45.17
3	a	SORTING (σ_G):	1.237	1.364	1.345	1.234	1.235
3	a	SKEWNESS (Sk_G):	0.000	0.240	0.207	0.000	0.000
3	a	KURTOSIS (K_G):	0.738	1.421	1.260	0.738	0.738
3	b	MEAN (M_Z):	4.465	4.448	4.435	4.470	4.469
3	b	SORTING (σ_I):	0.307	0.448	0.427	0.304	0.305
3	b	SKEWNESS (Sk_I):	0.000	-0.240	-0.207	0.000	0.000
3	b	KURTOSIS (K_G):	0.738	1.421	1.260	0.738	0.738
3	c	MEAN:	Very Coarse Silt	Very Coarse Silt	Very Coarse Silt	Very Coarse Silt	Very Coarse Silt
3	c	SORTING:	Very Well Sorted	Well Sorted	Well Sorted	Very Well Sorted	Very Well Sorted
3	c	SKEWNESS:	Symmetrical	Coarse Skewed	Coarse Skewed	Symmetrical	Symmetrical
3	c	KURTOSIS:	Platykurtic	Leptokurtic	Leptokurtic	Platykurtic	Platykurtic

Notes:

1. Descriptive data outlining sediment samples analysed and the analysts' description of sediment type, textural groups (sample type classiÿcations) and the full, technical granulometric sediment name re°ec ting variations in samples, ranging from uniform to heterogeneous, surveay area deposits

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Granulometric Analyses of Sediments within the Full Survey Area, January/February 2016

Physalia

Table E2n

			Sediment Samples			
			S 68	**S 69**	**S 70**	**S 71**
1		ANALYS + DATE	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016
		SIEVING ERROR:	N/A	N/A	N/A	N/A
		SAMPLE TYPE:	Unimodal, Very Well Sorted	Unimodal, Well Sorted	Unimodal, Very Well Sorted	Unimodal, Very Well Sorted
		TEXTURAL GROUP:	Slightly Gravelly Mud	Sandy Mud	Slightly Gravelly Mud	Mud
		SEDIMENT NAME:	Slightly Very Fine Gravelly Very Coarse Silt		Slightly Very Fine Gravelly Very Coarse Silt	Very Coarse Silt
2	a	MEAN $(\bar{x}_a)$:	51.61	57.48	63.44	49.14
		SORTING (σ_a):	77.63	37.89	174.7	13.23
		SKEWNESS (Sk_a)	26.68	7.840	12.95	12.83
		KURTOSIS (K_a):	757.0	107.1	172.0	228.5
	b	MEAN $(\bar{x}_g)$:	45.79	50.04	47.20	45.79
		SORTING (σ_g):	1.204	1.390	1.417	1.146
		SKEWNESS (Sk_g)	14.71	3.351	9.065	8.035
		KURTOSIS (K_g):	267.1	14.89	93.96	77.00
	c	MEAN $(\bar{x}_\phi)$:	4.449	4.321	4.405	4.449
		SORTING (σ_ϕ):	0.268	0.476	0.502	0.197
		SKEWNESS (Sk_ϕ):	-14.710	-3.351	-9.065	-8.035
		KURTOSIS (K_ϕ):	267.1	14.89	93.96	77.00
3	a	MEAN (M_G):	45.19	46.90	45.40	45.27
		SORTING (σ_G):	1.235	1.374	1.239	1.237
		SKEWNESS (Sk_G)	0.000	0.222	0.000	0.000
		KURTOSIS (K_G):	0.738	1.327	0.738	0.738
	b	MEAN (M_Z):	4.468	4.414	4.461	4.465
		SORTING (σ_I):	0.305	0.458	0.309	0.307
		SKEWNESS (Sk_I)	0.000	-0.222	0.000	0.000
		KURTOSIS (K_G):	0.738	1.327	0.738	0.738
	c	MEAN:	Very Coarse Silt	Very Coarse Silt	Very Coarse Silt	Very Coarse Silt
		SORTING:	Very Well Sorted	Well Sorted	Very Well Sorted	Very Well Sorted
		SKEWNESS:	Symmetrical	Coarse Skewed	Symmetrical	Symmetrical
		KURTOSIS:	Platykurtic	Leptokurtic	Platykurtic	Platykurtic

Notes:

1. Descriptive data outlining sediment samples analysed and the analysts' description of sediment type, textural groups (sample type classiÿcations) and the full, technical granulometric sediment name re°ec ting variations in samples, ranging from uniform to heterogeneous, surveay area deposits

2. Mathematical descriptions of sediment types based on "Methods of Moments" divided into a). arithmetic method of moments, b). geometric method of moments and c). logarithmic method of moments

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Physalia

Granulometric Analyses of Sediments within the Full Survey Area, January/February 2016

Table E2o

			Sediment Samples		
			S 72	S 73	S 74
1		ANALYS + DATE	Physalia; February 2016	Physalia; February 2016	Physalia; February 2016
1		SIEVING ERROR:	N/A	N/A	N/A
1		SAMPLE TYPE:	Unimodal, Very Well Sorted	Unimodal, Very Well Sorted	Unimodal, Very Well Sorted
1		TEXTURAL GROUP:	Mud	Mud	Slightly Gravelly Mud
1		SEDIMENT NAME:	Very Coarse Silt	Very Coarse Silt	
2	a	MEAN $(\bar{x}_a)$:	49.94	49.00	48.67
2	a	SORTING (σ_a):	17.70	12.33	41.40
2	a	SKEWNESS (Sk_a):	18.24	14.71	53.59
2	a	KURTOSIS (K_a):	566.5	308.6	3021.4
2	b	MEAN $(\bar{x}_g)$:	46.23	45.75	45.15
2	b	SORTING (σ_g):	1.178	1.137	1.108
2	b	SKEWNESS (Sk_g):	6.728	8.130	25.77
2	b	KURTOSIS (K_g):	58.73	82.37	806.0
2	c	MEAN $(\bar{x}_\phi)$:	4.435	4.450	4.469
2	c	SORTING (σ_ϕ):	0.236	0.185	0.148
2	c	SKEWNESS (Sk_ϕ):	-6.728	-8.130	-25.773
2	c	KURTOSIS (K_ϕ):	58.73	82.37	806.0
3	a	MEAN (M_G):	45.47	45.27	44.97
3	a	SORTING (σ_G):	1.240	1.237	1.232
3	a	SKEWNESS (Sk_G):	0.000	0.000	0.000
3	a	KURTOSIS (K_G):	0.738	0.738	0.738
3	b	MEAN (M_Z):	4.459	4.465	4.475
3	b	SORTING (σ_I):	0.310	0.307	0.301
3	b	SKEWNESS (Sk_I):	0.000	0.000	0.000
3	b	KURTOSIS (K_G):	0.738	0.738	0.738
3	c	MEAN:	Very Coarse Silt	Very Coarse Silt	Very Coarse Silt
3	c	SORTING:	Very Well Sorted	Very Well Sorted	Very Well Sorted
3	c	SKEWNESS:	Symmetrical	Symmetrical	Symmetrical
3	c	KURTOSIS:	Platykurtic	Platykurtic	Platykurtic

Notes:

1. Descriptive data outlining sediment samples analysed and the analysts' description of sediment type, textural groups (sample type classiÿcations) and the full, technical granulometric sediment name re°ec ting variations in samples, ranging from uniform to heterogeneous, surveay area deposits

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3. Folk and Ward descriptive sediment granulometric method of sediment description based on a). logarithmic and b). graphical methods along with a reÿned textural description system addressing features comprising sorting, skewness and kurtosis.

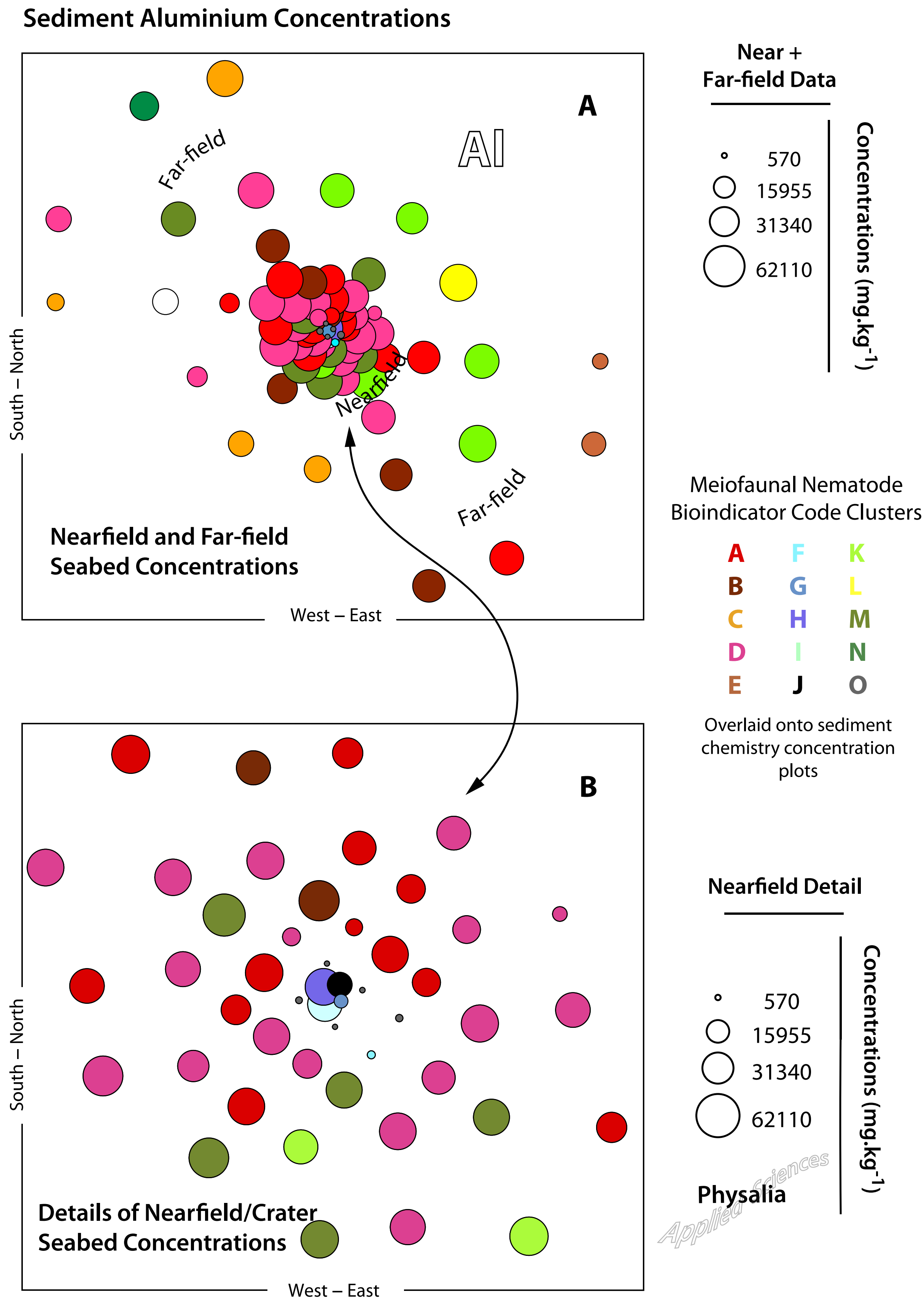

Figure E6. Sediment aluminium concentration distributions in (A) the full survey area and (B) in the nearfield sampling stations including the blow-out site.

Sediment Arsenic Concentrations

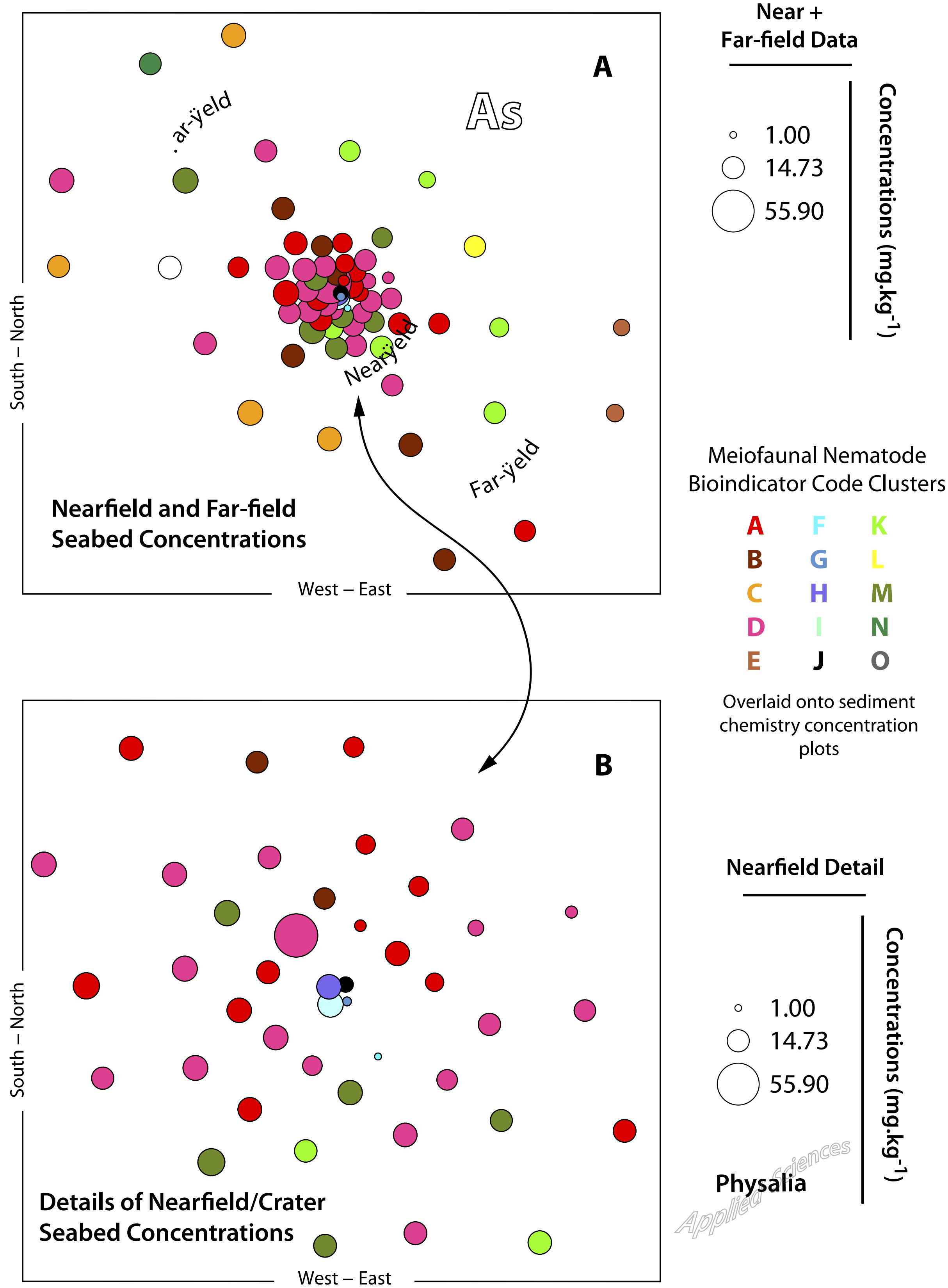

Figure E7. Sediment arsenic concentration distributions in (A) the full survey area and (B) in the nearfield sampling stations including the blow-out site.

Sediment Barium Concentrations

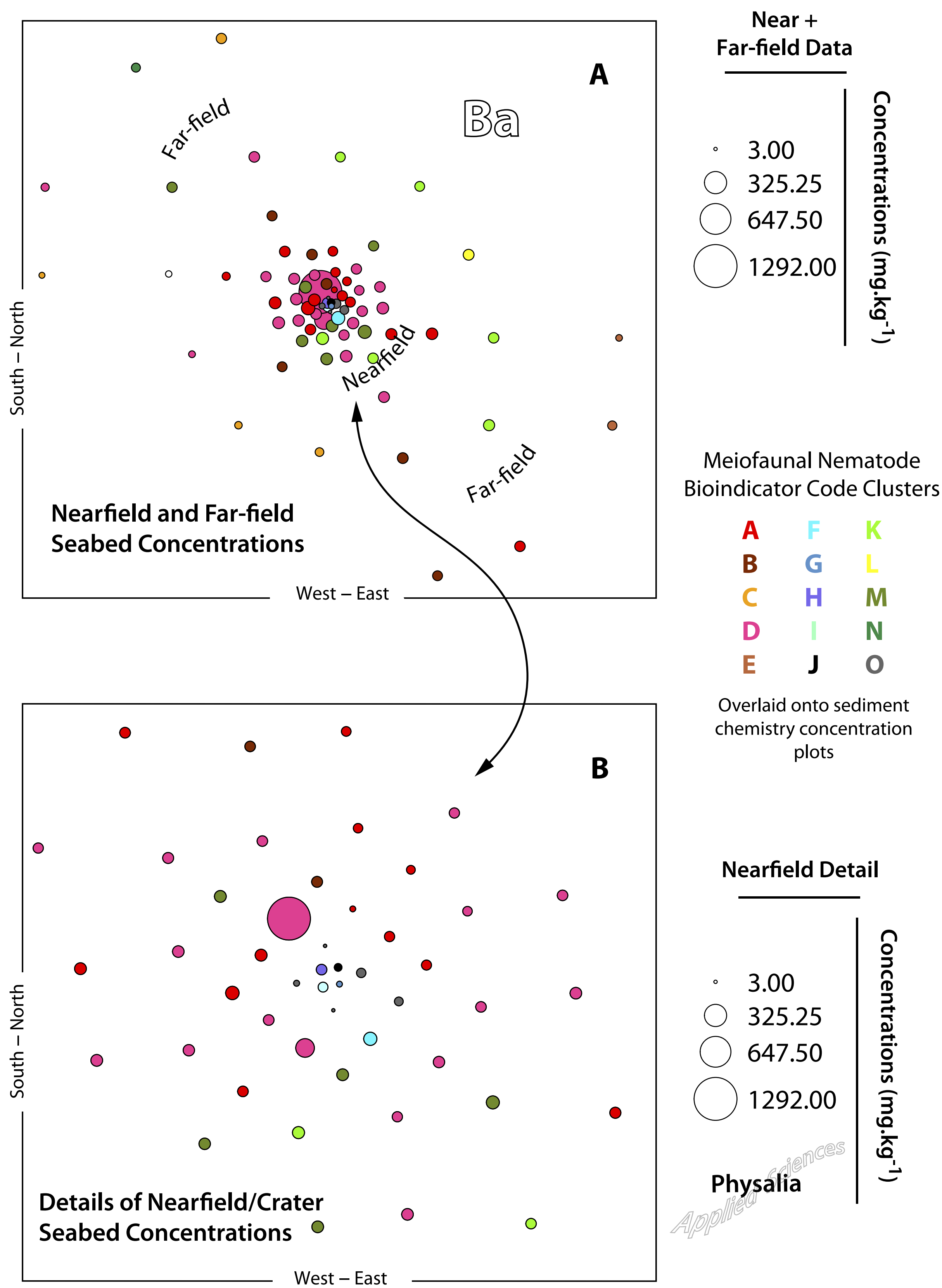

Figure E8. Sediment barium concentration distributions in (A) the full survey area and (B) in the nearfield sampling stations including the blow-out site.

Sediment Calcium Concentrations

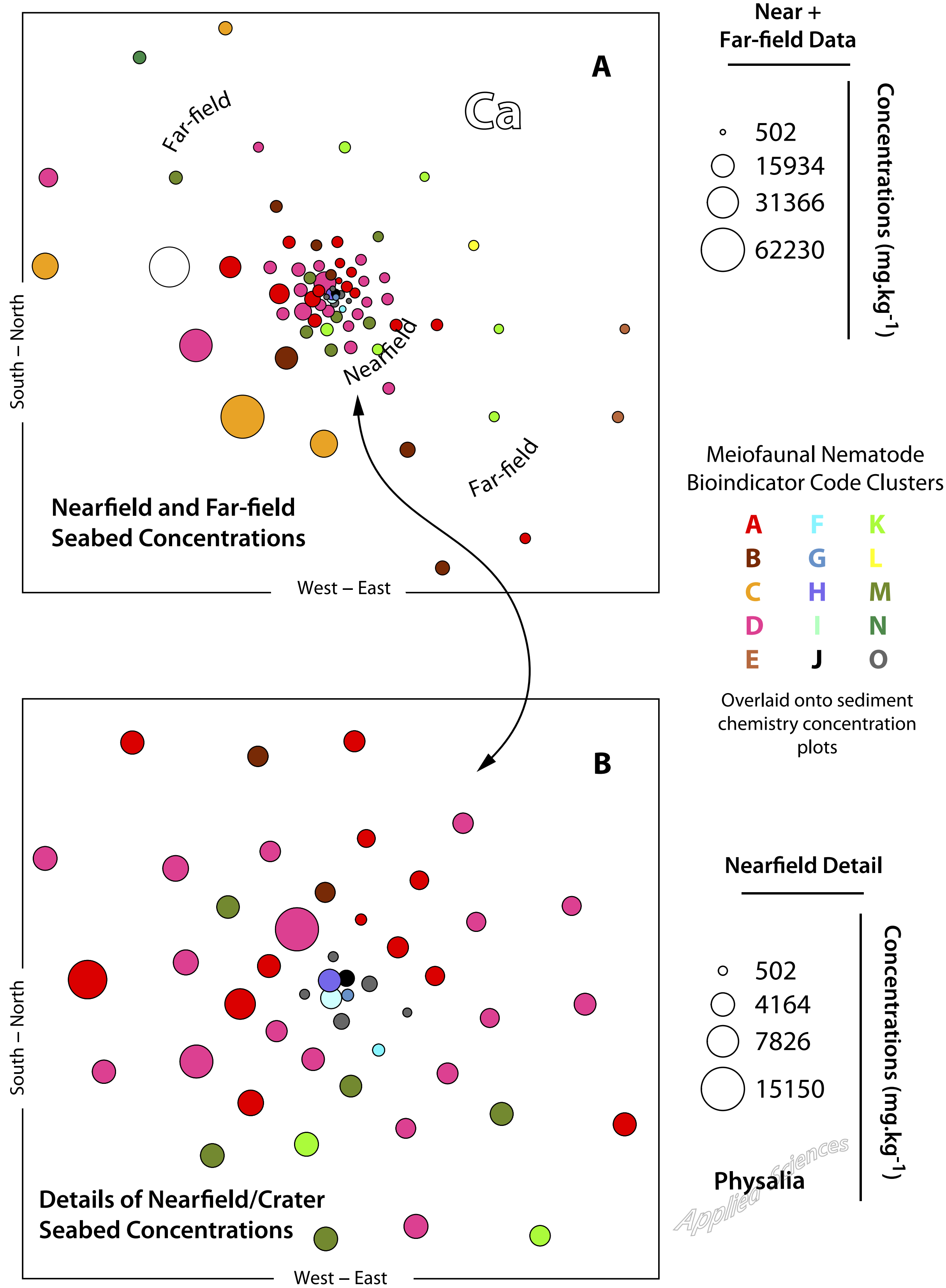

Figure E9. Sediment calcium concentration distributions in (A) the full survey area and (B) in the nearfield sampling stations including the blow-out site.

Sediment Chromium Concentrations

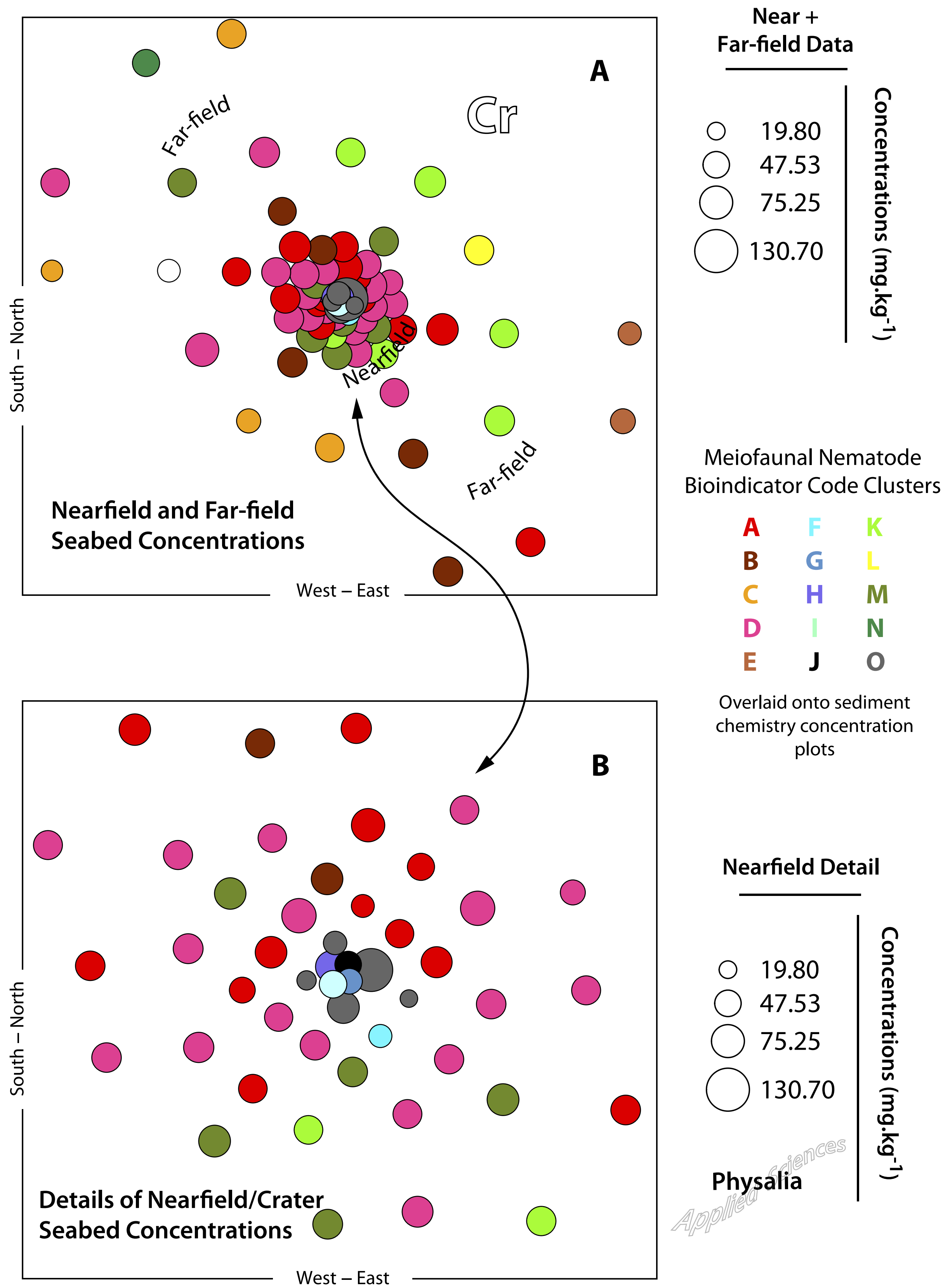

Figure E10. Sediment chromium concentration distributions in (A) the full survey area and (B) in the nearfield sampling stations including the blow-out site.

Sediment Copper Concentrations

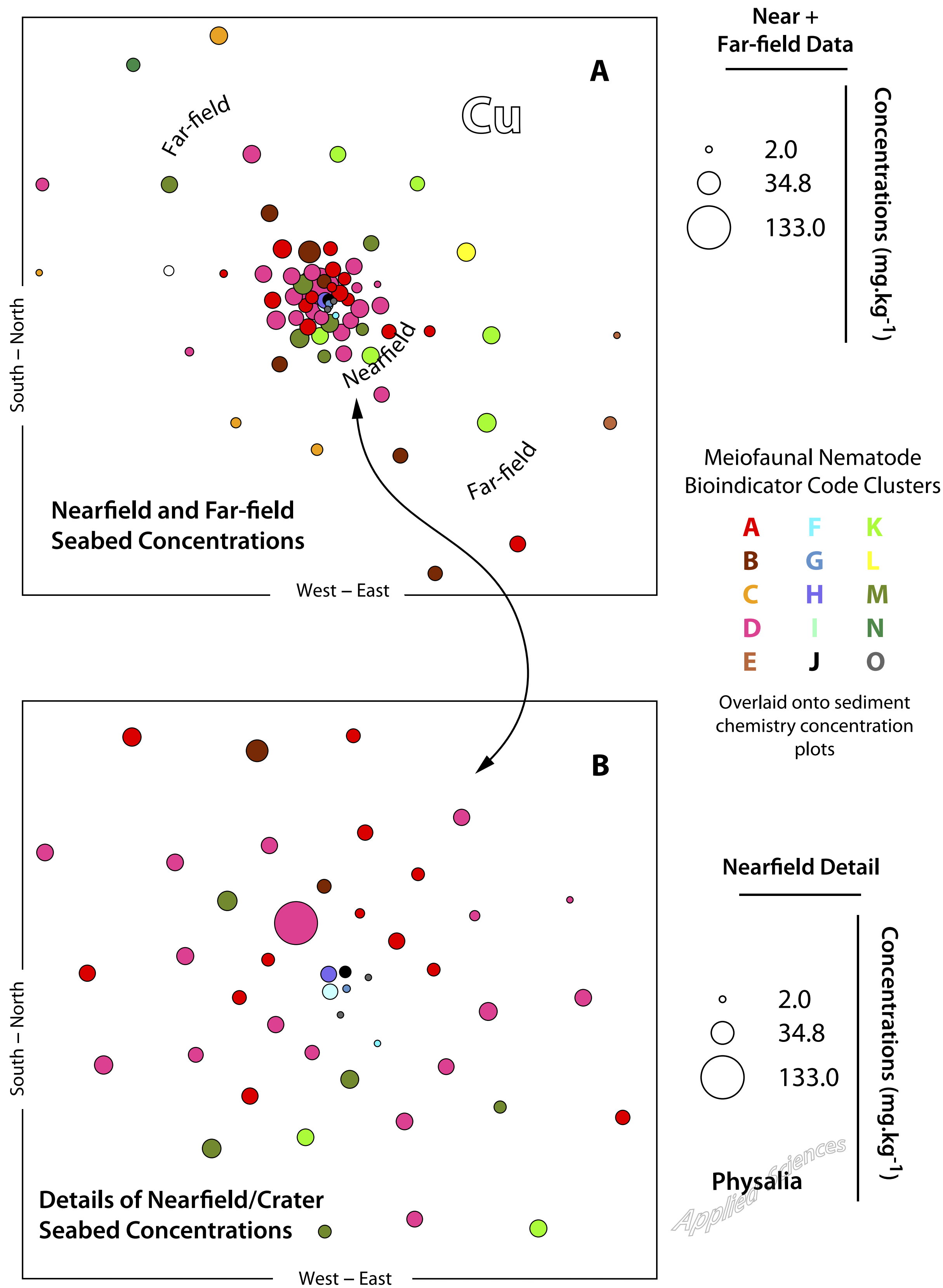

Figure E11. Sediment copper concentration distributions in (A) the full survey area and (B) in the nearfield sampling stations including the blow-out site.

Sediment Iron Concentrations

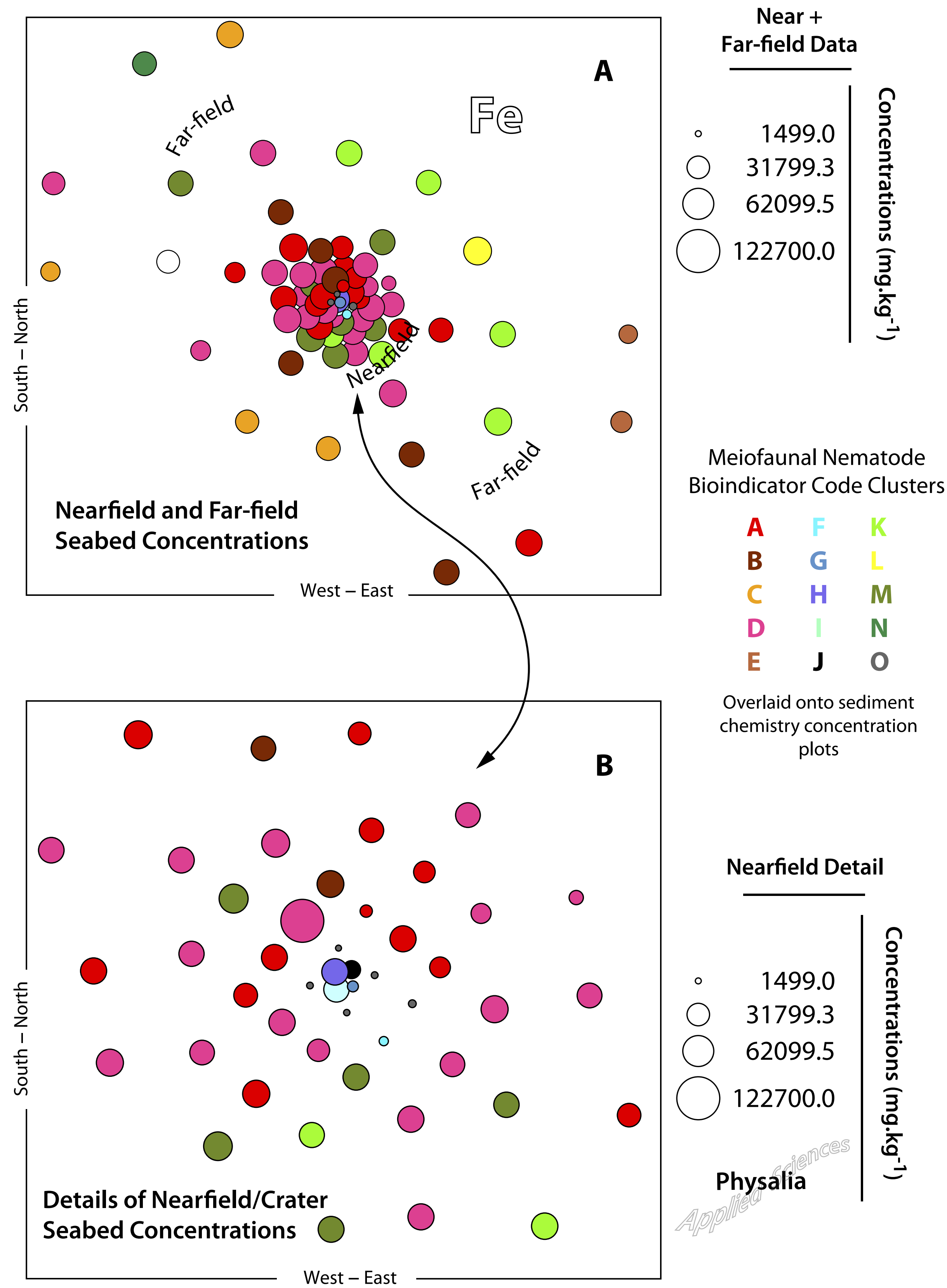

Figure E12. Sediment iron concentration distributions in (A) the full survey area and (B) in the nearfield sampling stations including the blow-out site.

Sediment Lead Concentrations

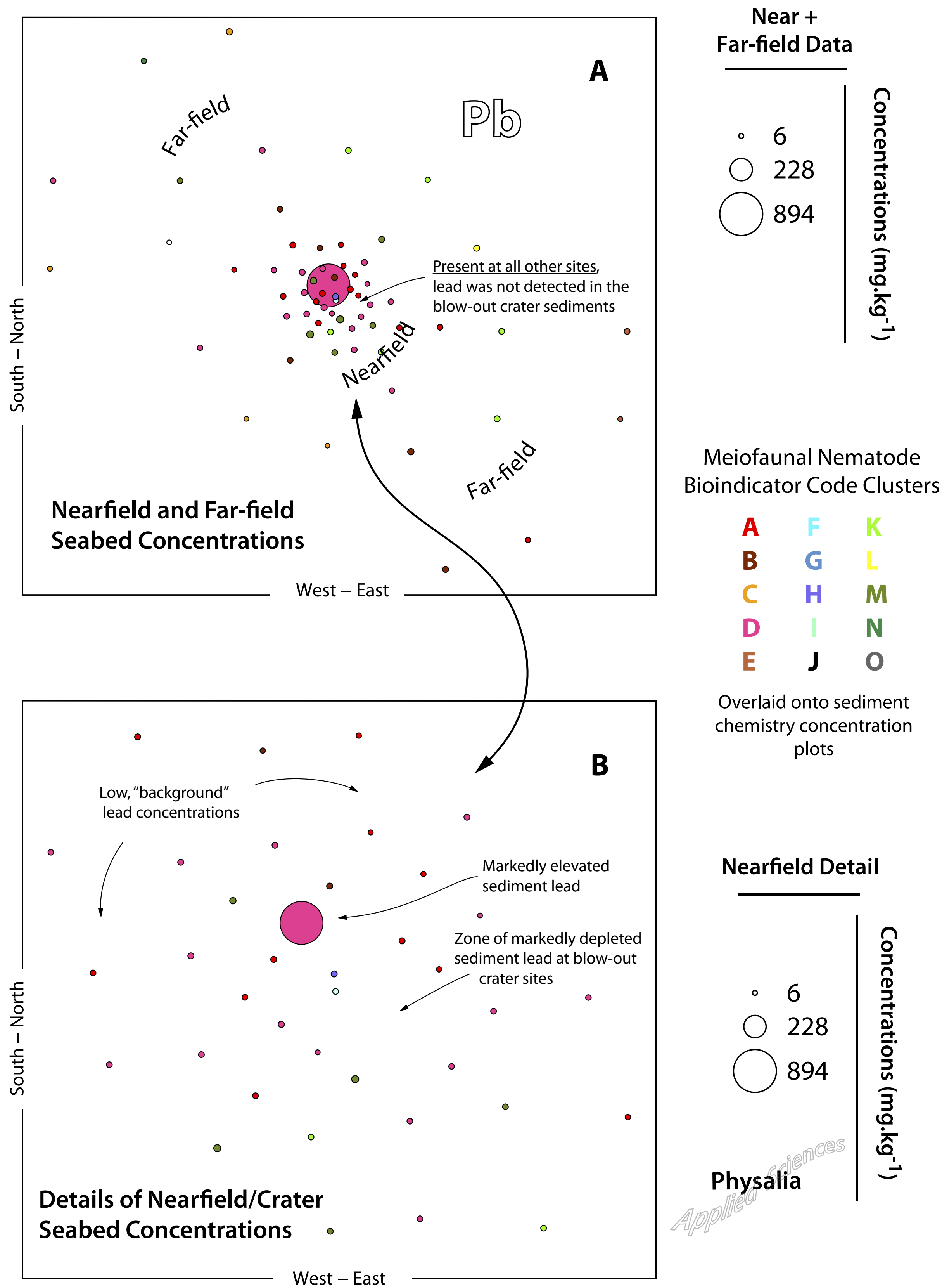

Figure E13. Sediment lead concentration distributions in (A) the full survey area and (B) in the nearfield sampling stations including the blow-out site.

Sediment Magnesium Concentrations

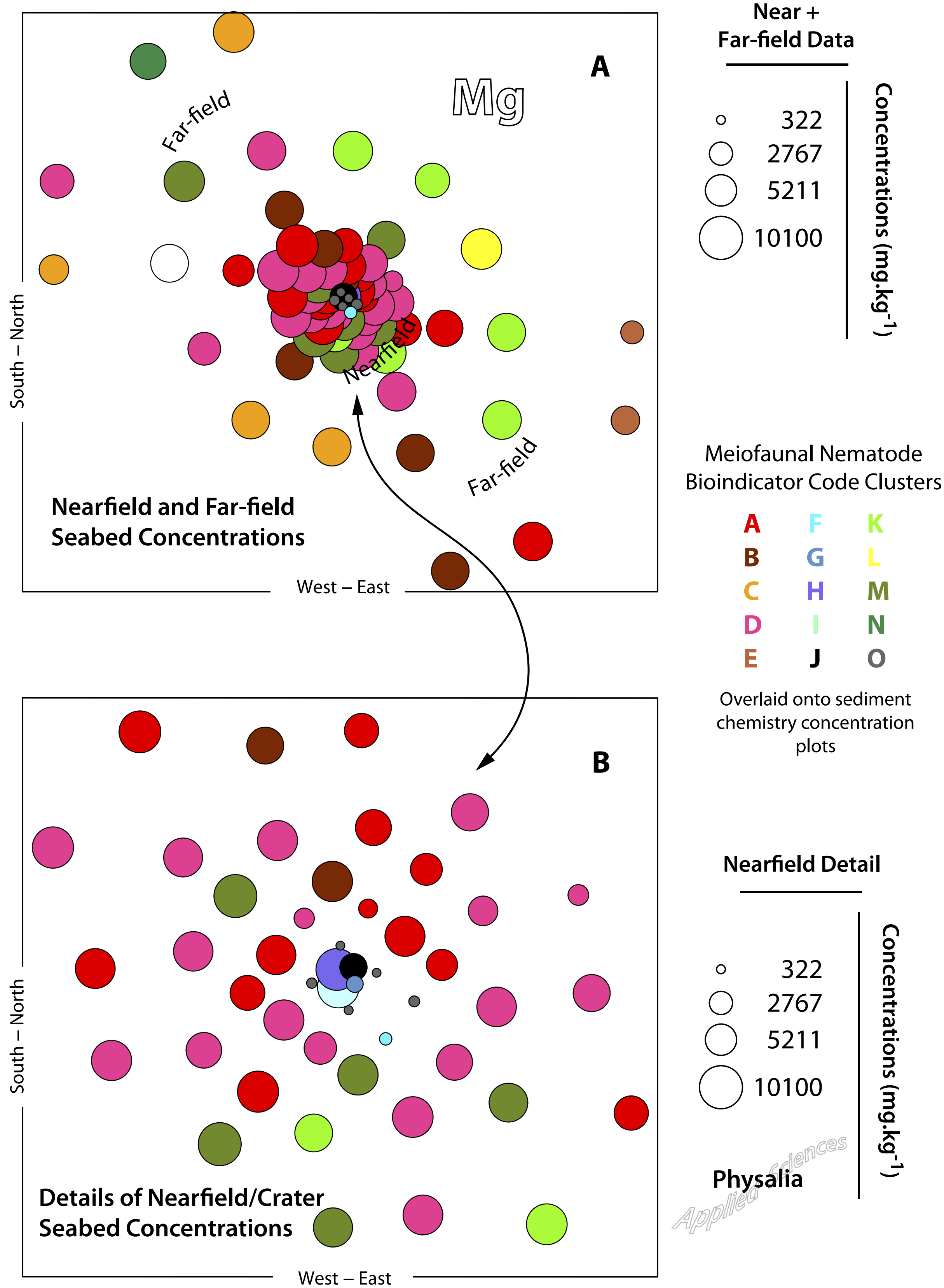

Figure E14. Sediment magnesium concentration distributions in (A) the full survey area and (B) in the nearfield sampling stations including the blow-out site.

Sediment Manganese Concentrations

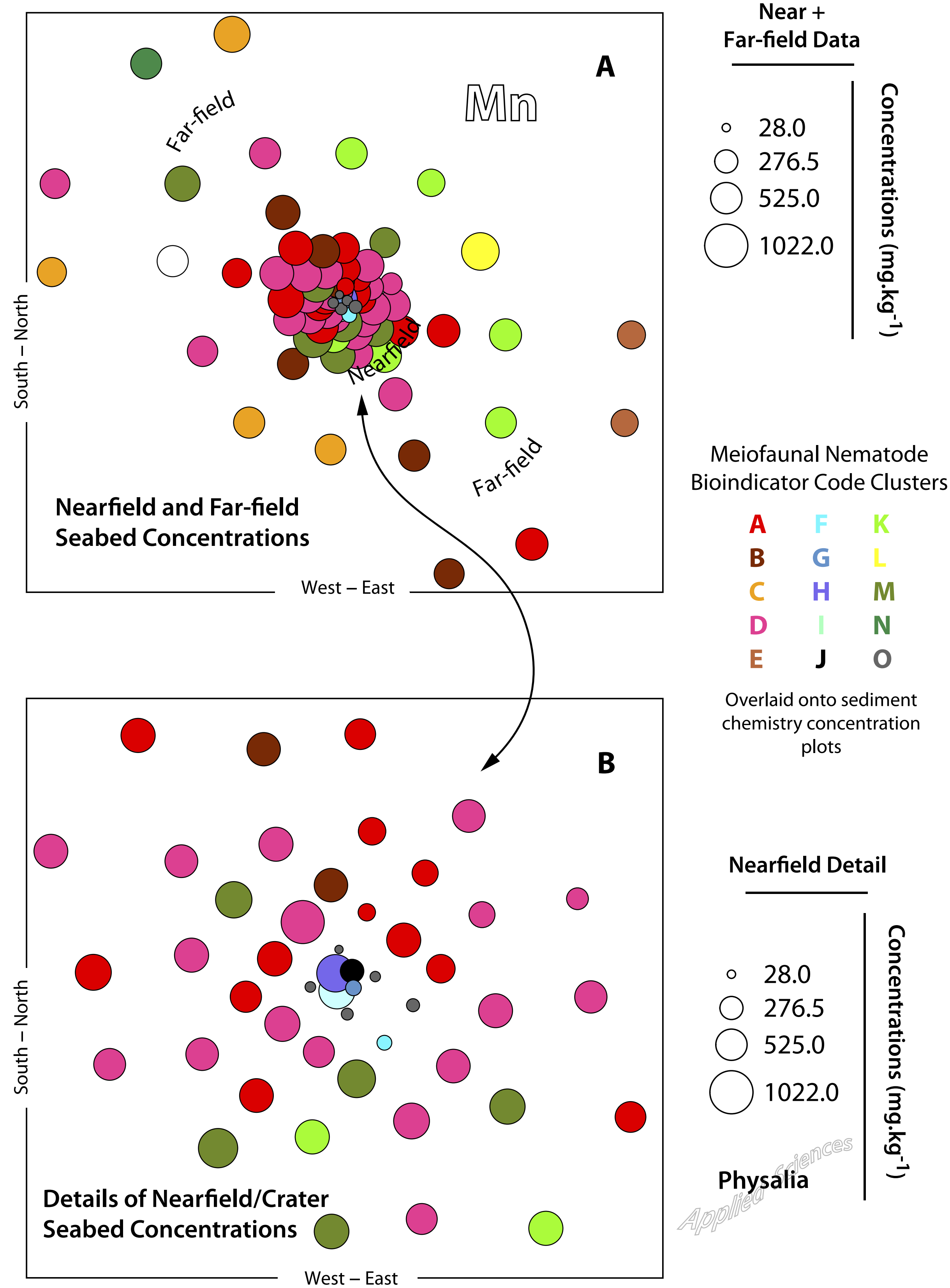

Figure E15. Sediment manganese concentration distributions in (A) the full survey area and (B) in the nearfield sampling stations including the blow-out site.

Sediment Potassium Concentrations

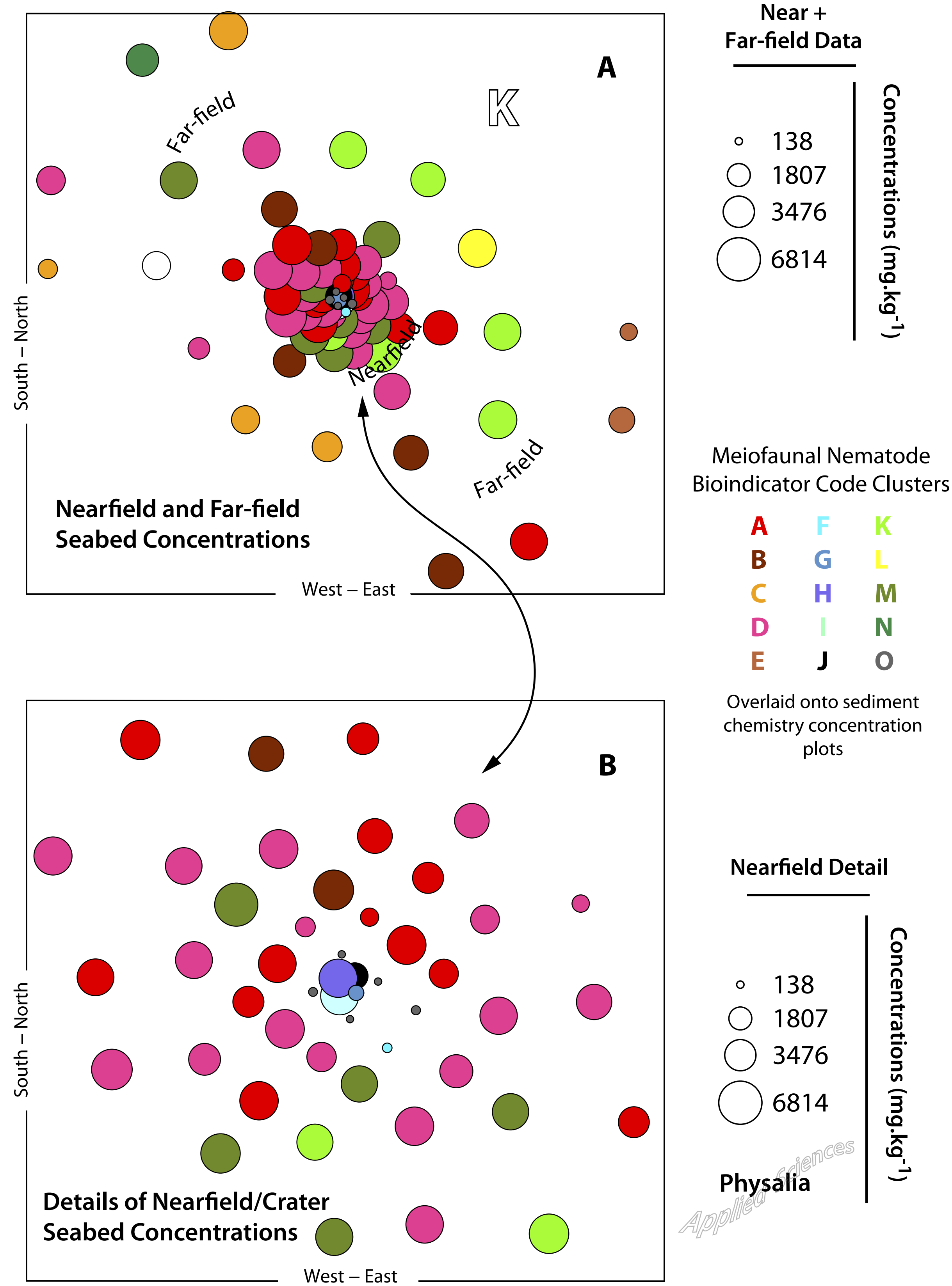

Figure E18. Sediment potassium concentration distributions in (A) the full survey area and (B) the nearfield sampling stations adjacent to the blow-out site.

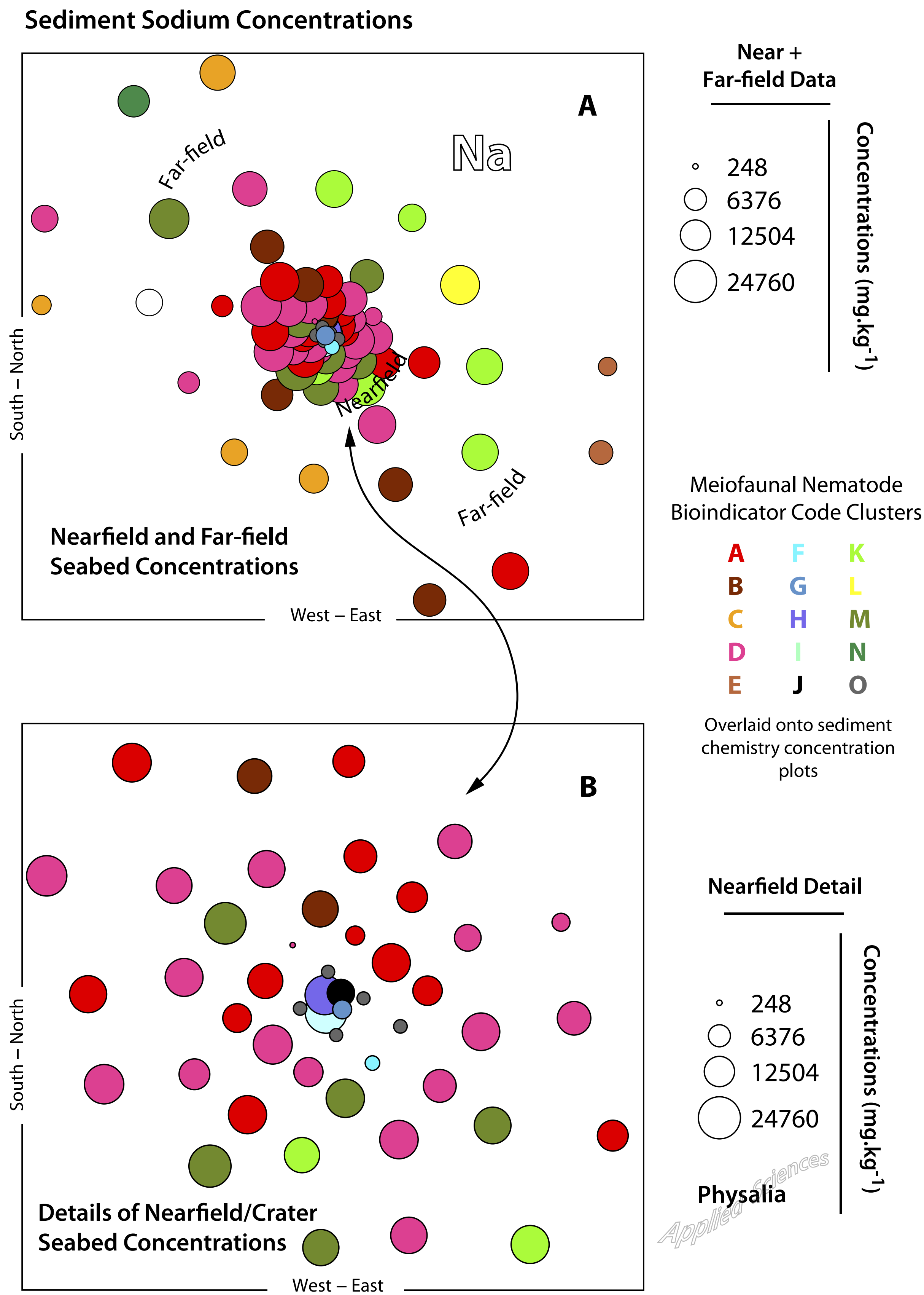

Figure E19. Sediment sodium concentration distributions in (A) the full survey area and (B) the nearfield sampling stations adjacent to the blow-out site.

Sediment Strontium Concentrations

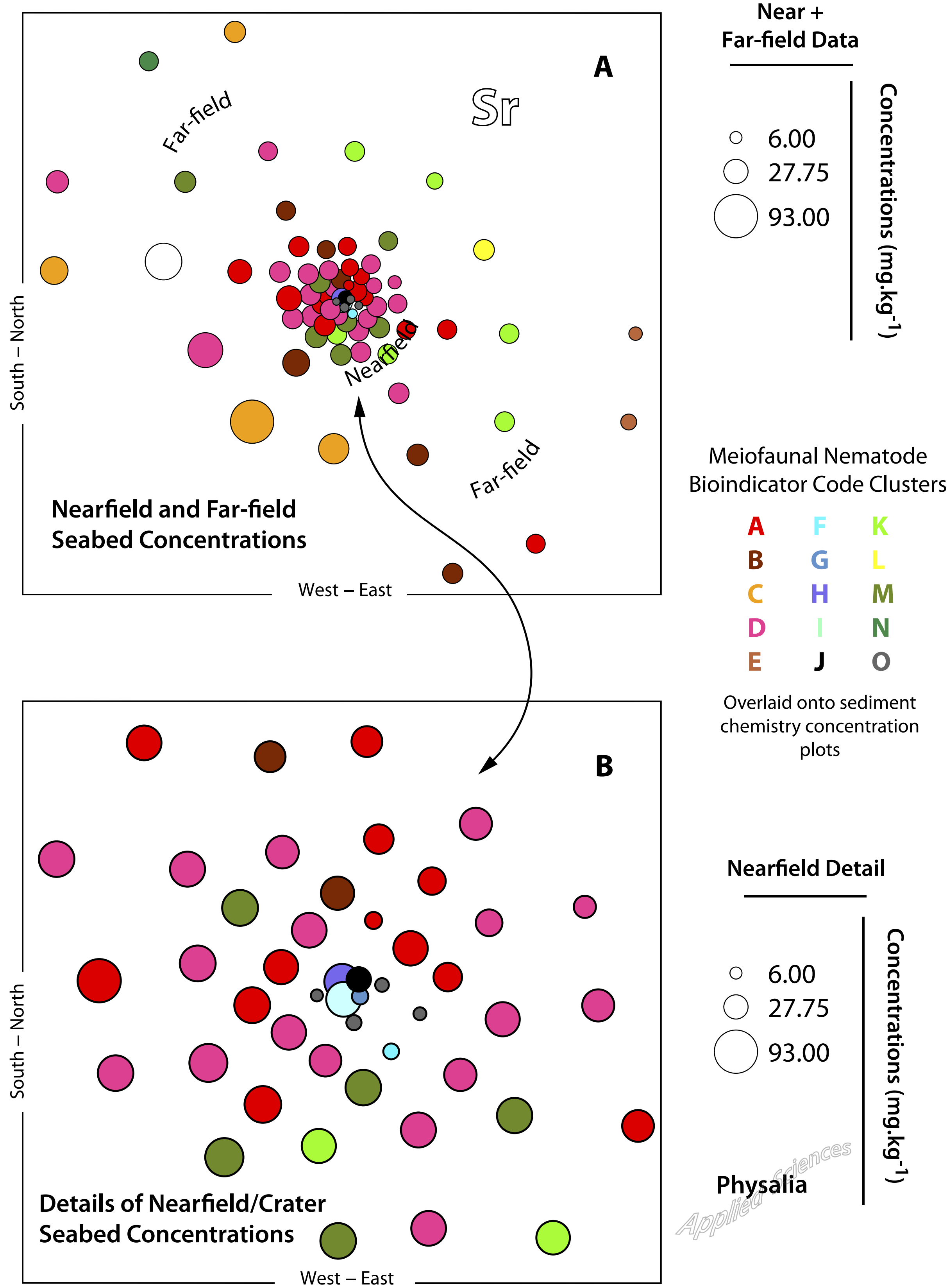

Figure E20. Sediment strontium concentration distributions in (A) the full survey area and (B) the nearfield sampling stations adjacent to the blow-out site.

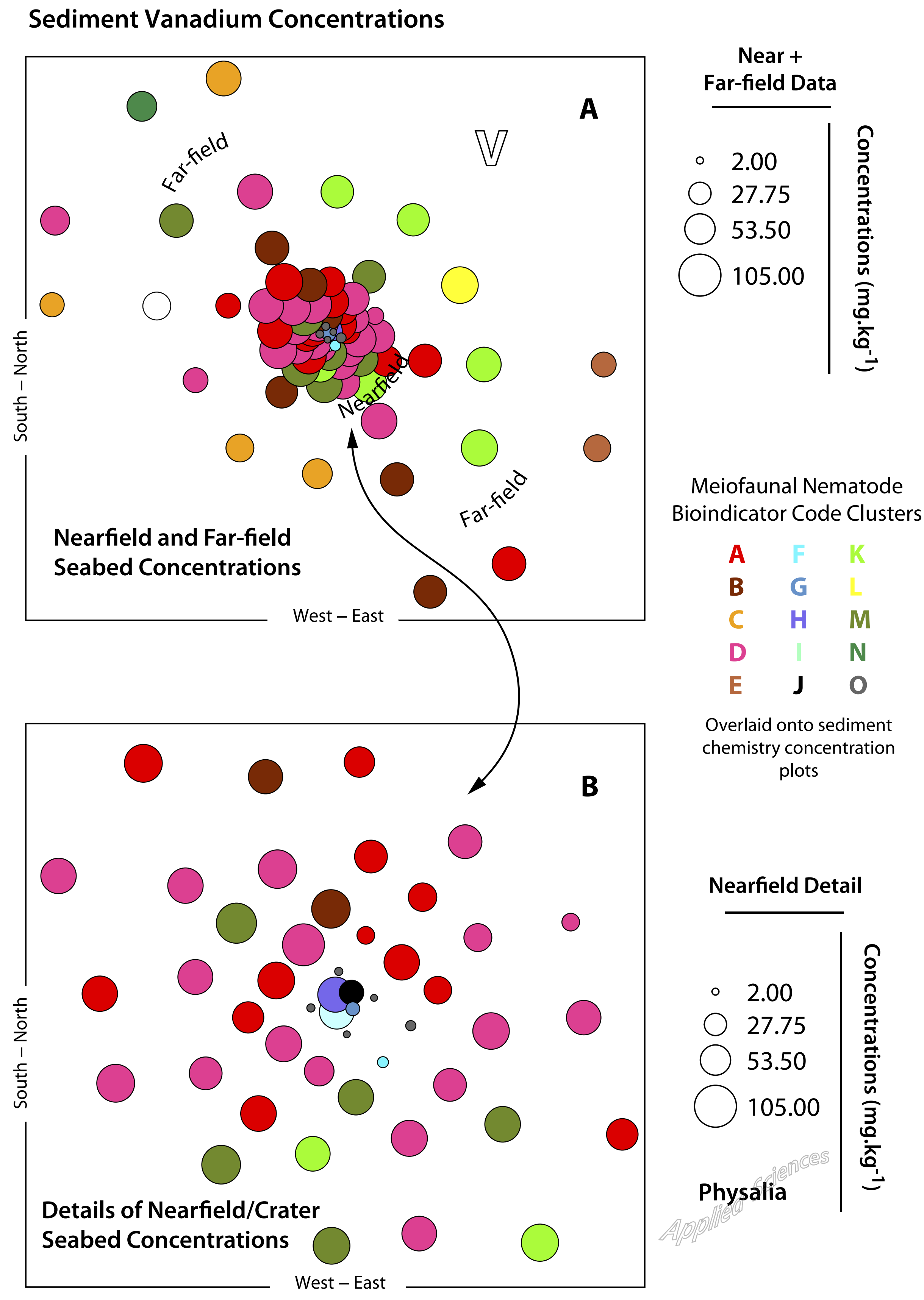

Figure E21. Sediment vanadium concentration distributions in (A) the full survey area and (B) the nearfield sampling stations adjacent to the blow-out site.

Sediment Zinc Concentrations

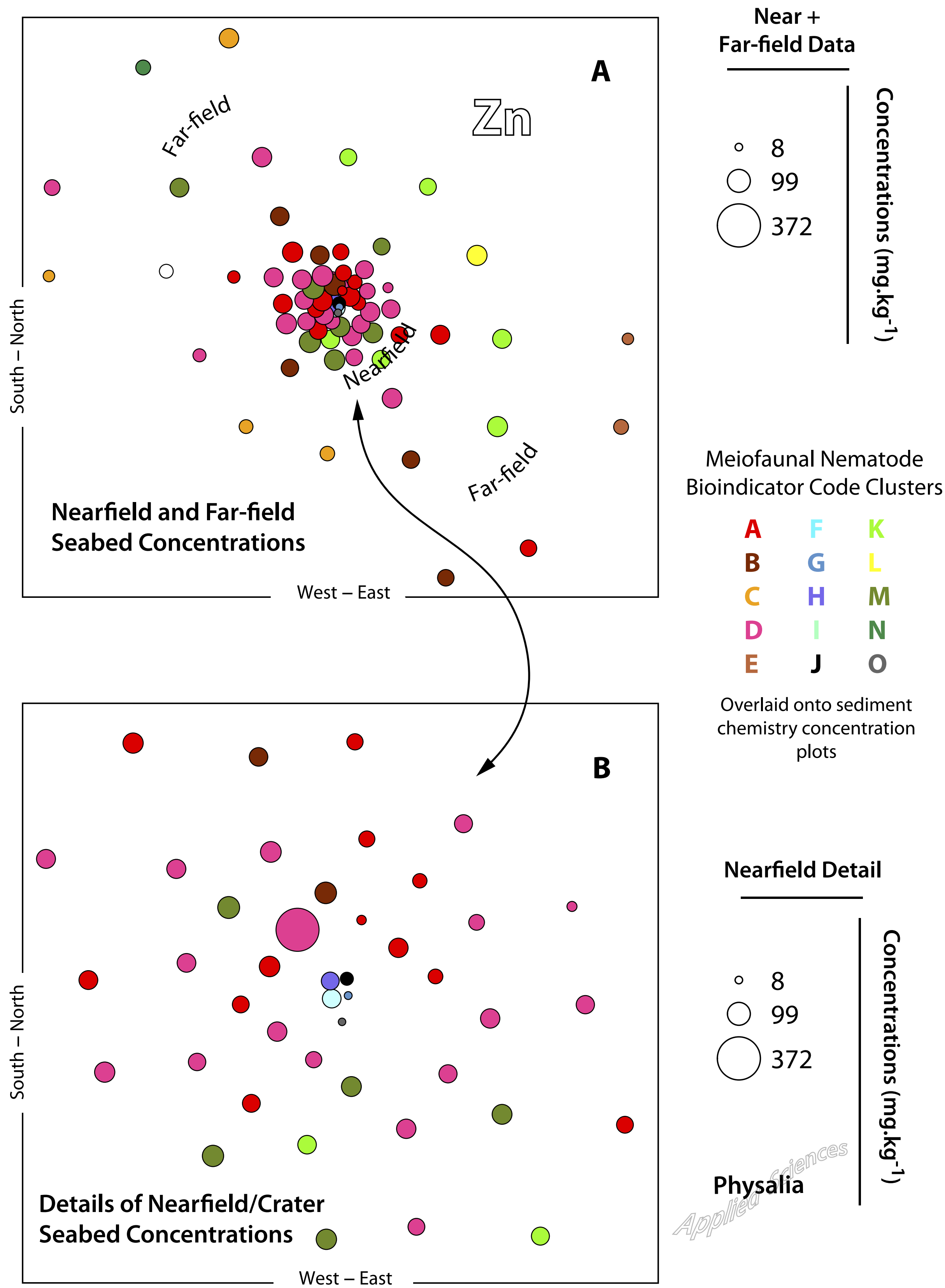

Figure E22. Sediment zinc concentration distributions in (A) the full survey area and (B) the nearfield sampling stations adjacent to the blow-out site.

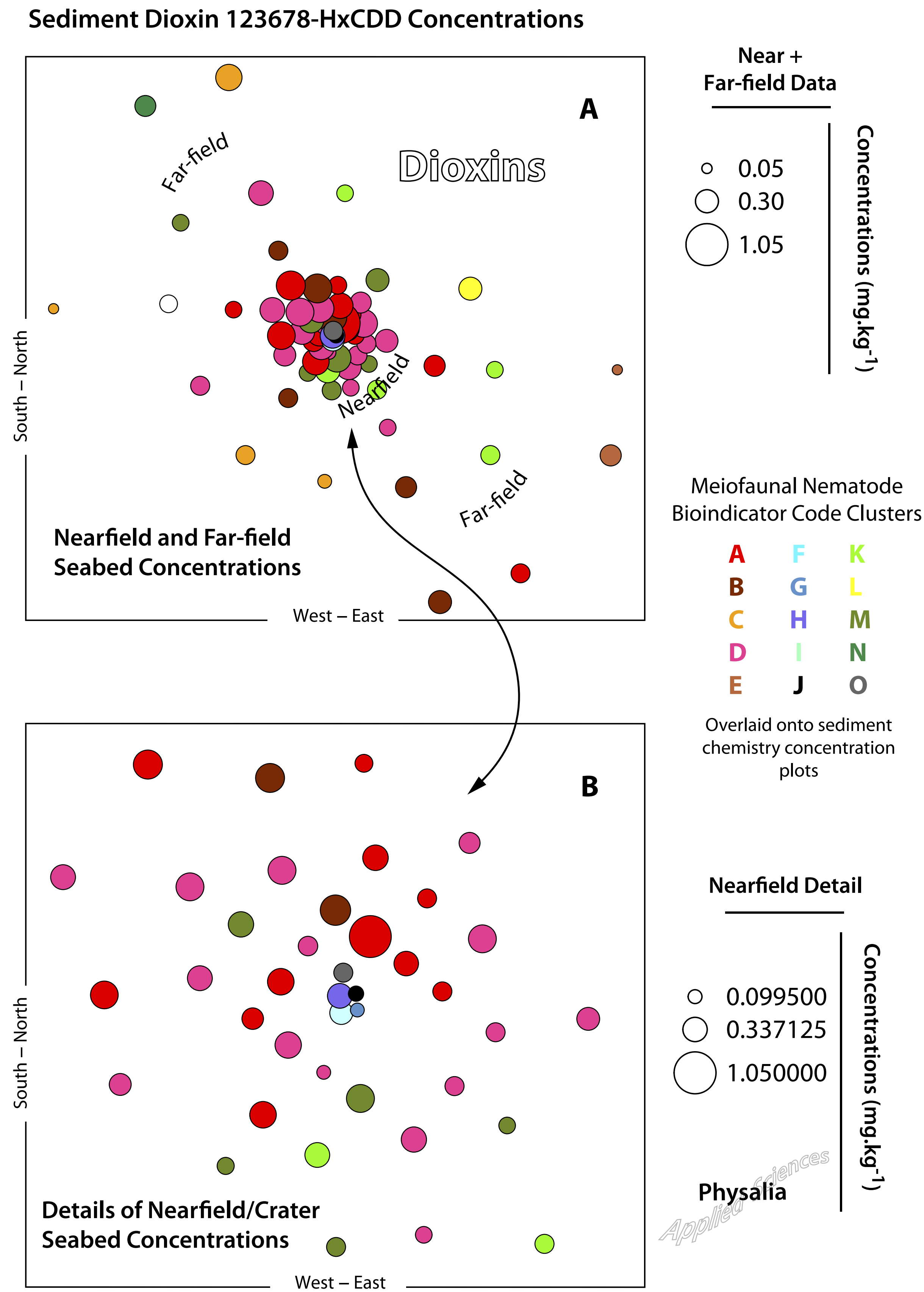

Figure E23 Sediment dioxin 1,2,3,6,7,8-HxCDD concentration distributions in the full survey area (A) and in the nearfield sampling statistions (B)

Sediment Dioxins ∑2378-Dioxin Concentrations

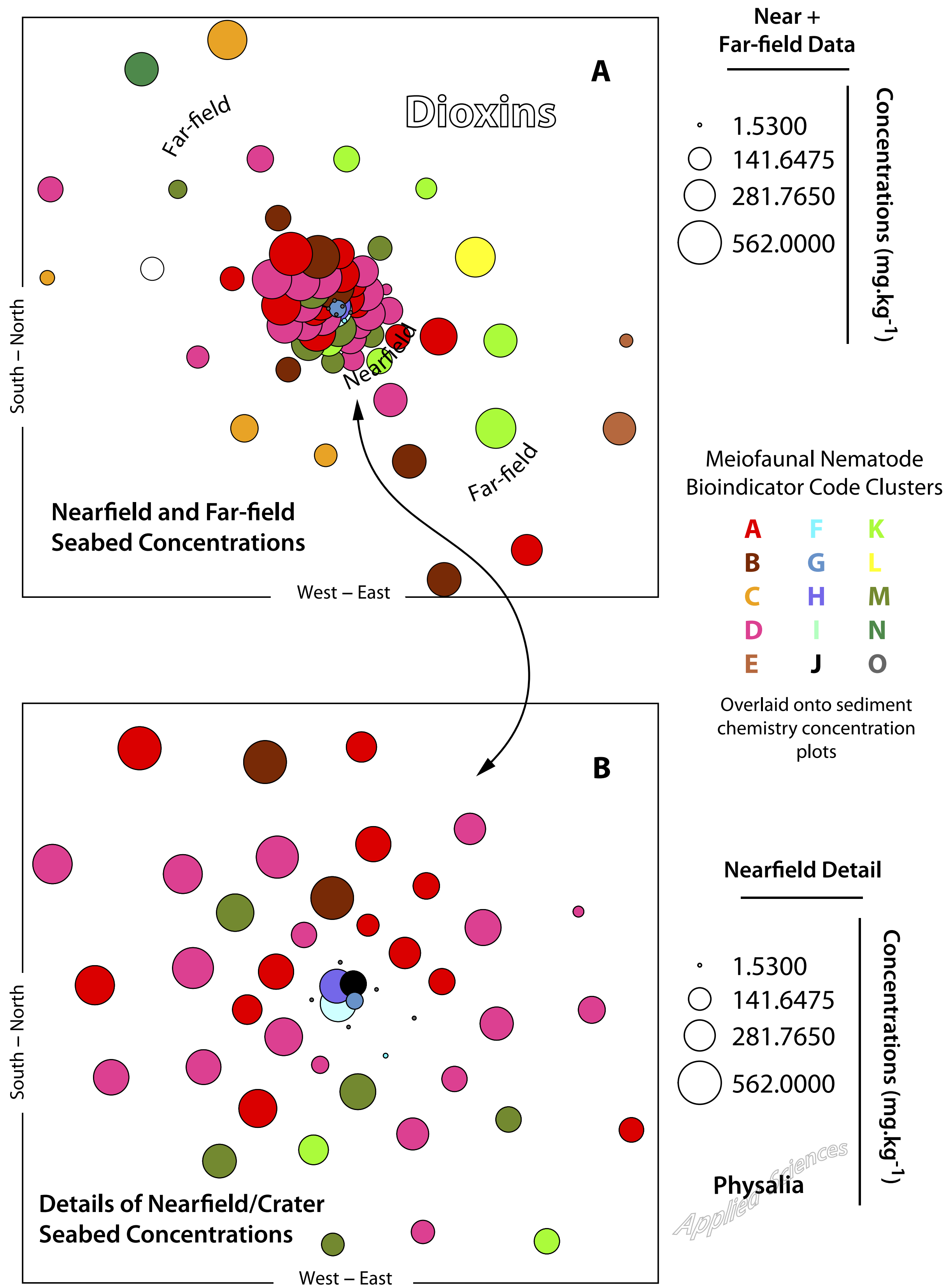

Figure E24 Sediment total 2,3,7,8-Dioxin concentration distributions in the full survey area (A) and in the nearfield sampling statistions (B)

Sediment Dioxins 123478-HxCDD Concentrations

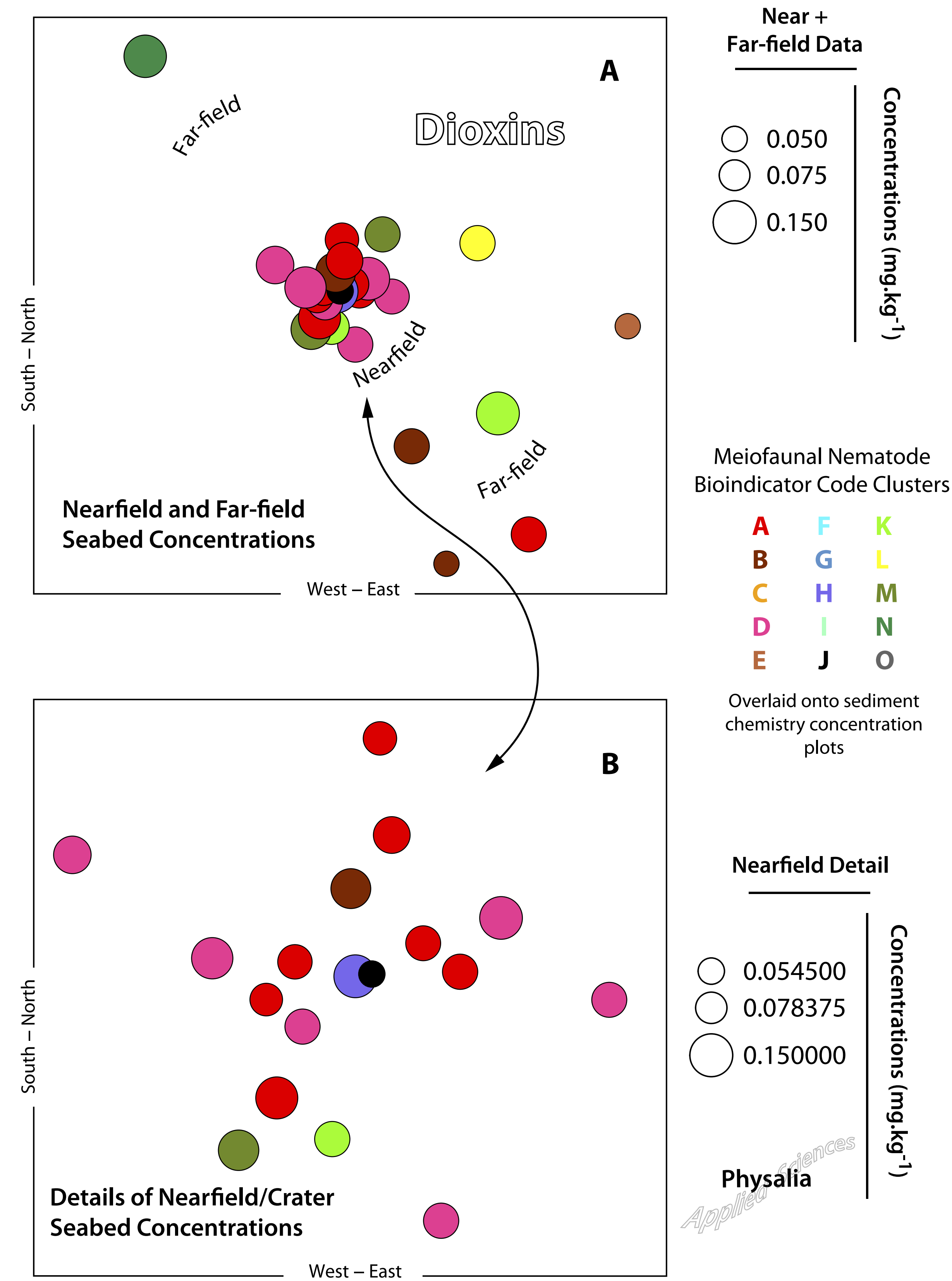

Figure E25. Dioxin 1,2,3,4,7,8-HxCDD concentration distributions in (A) the full survey area and (B) the nearfield sampling stations adjacent to the blow-out site.

Sediment OCDF Concentrations

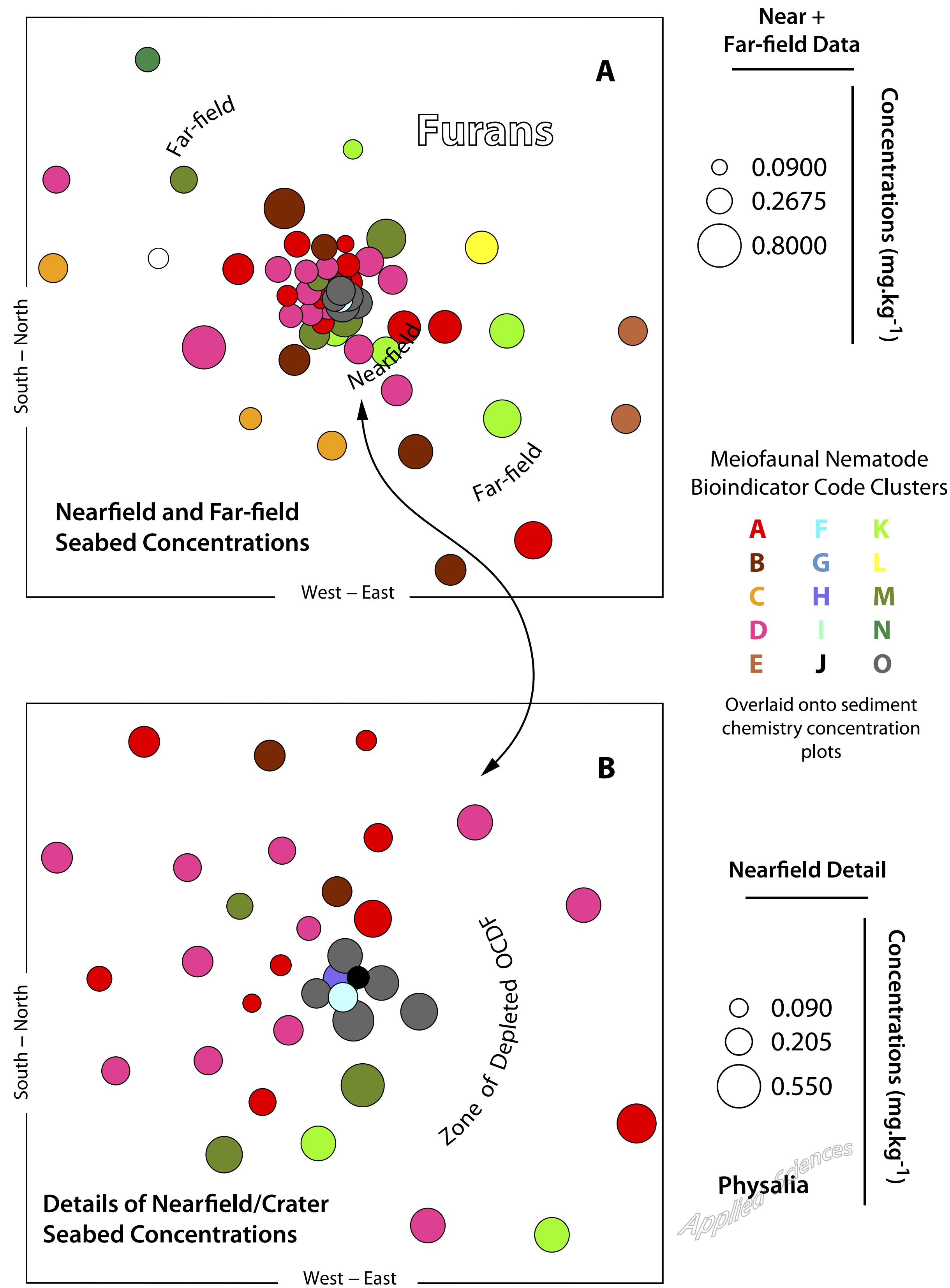

Figure E26. Sediment Furan OCDF concentration distributions in the full survey area (A) and in the near-field sampling statistions (B). Note zone of depletion of OCDF concentrations in the nearfield sediments

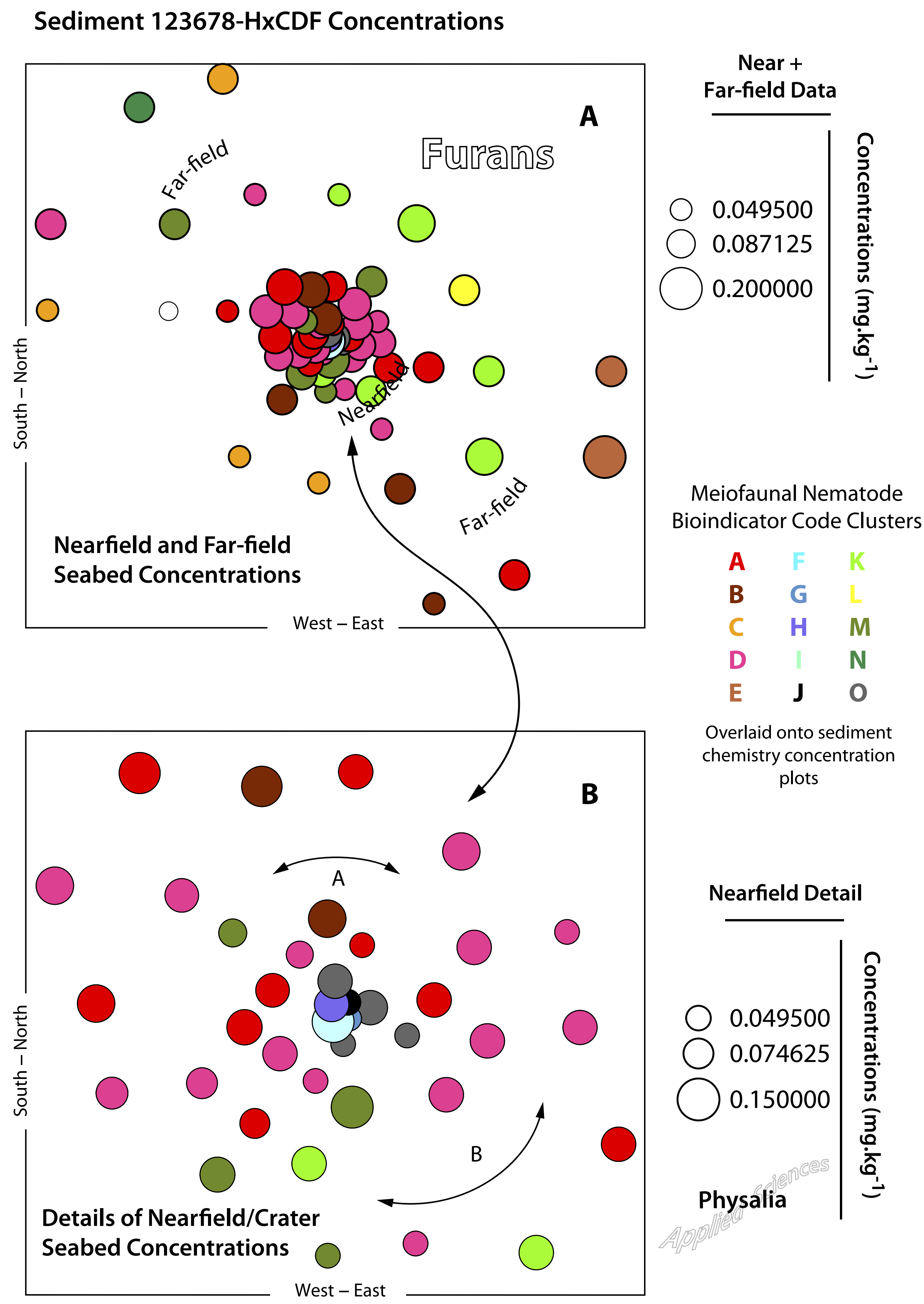

Figure E27. Sediment furan 1,2,3,6,7,8-HxCDF concentration distributions in the full survey area (A) and in the nearfield sampling statistions (B). Note the zones of depletion of this furan in the nearfield site sediment sites A and B

Sediment 23478-PCDF Concentrations

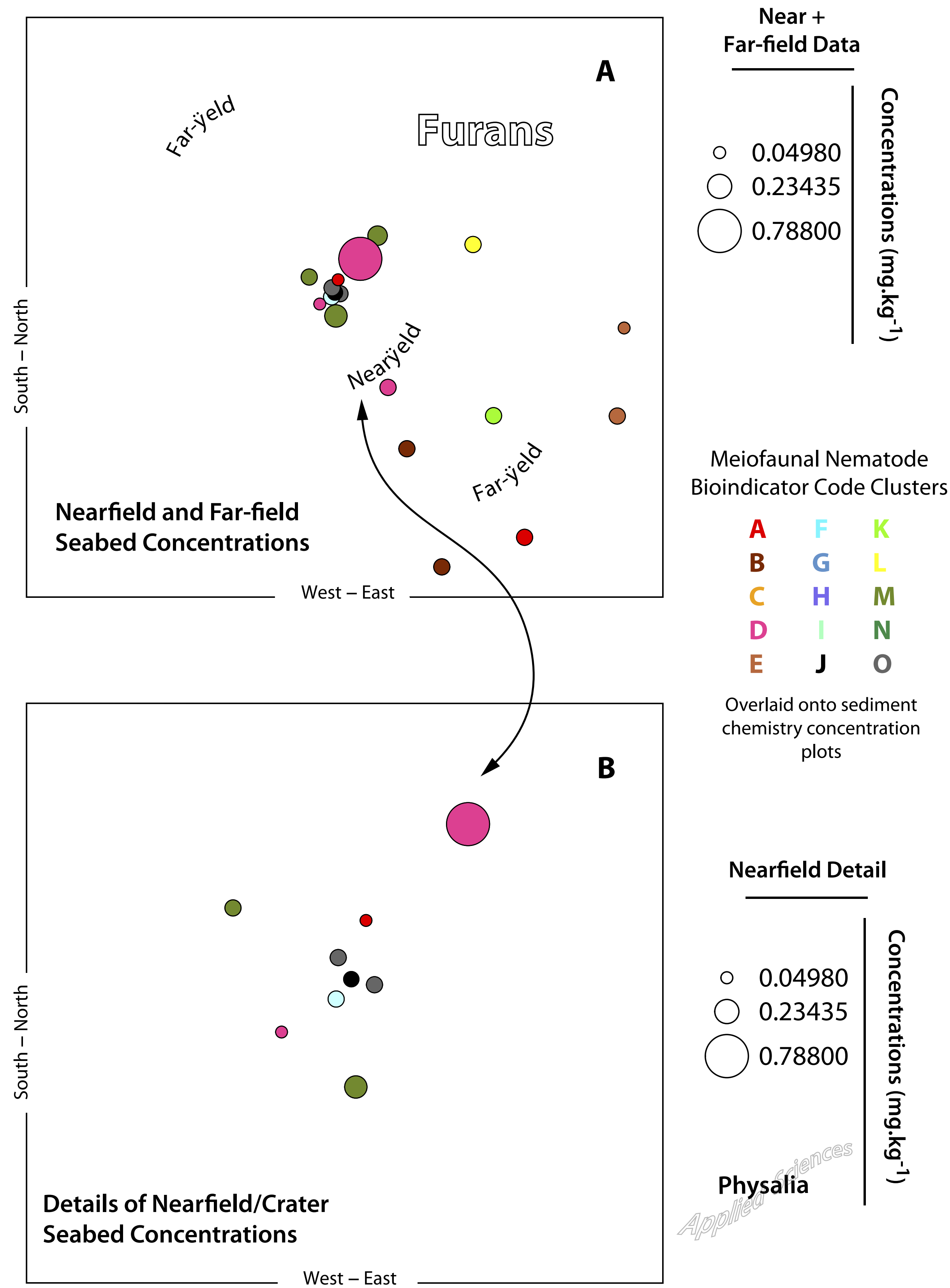

Figure E28. Sediment furan 2,3,4,7,8-PCDF concentration distributions in the full survey area (A) and in the nearÿeld sampling stations (B). Note the concentration of this furan at sites surrounding the blow out site accompanied by detects at sites extending o° shore of the former production platform.

Sediment 2378-TCDF Concentrations

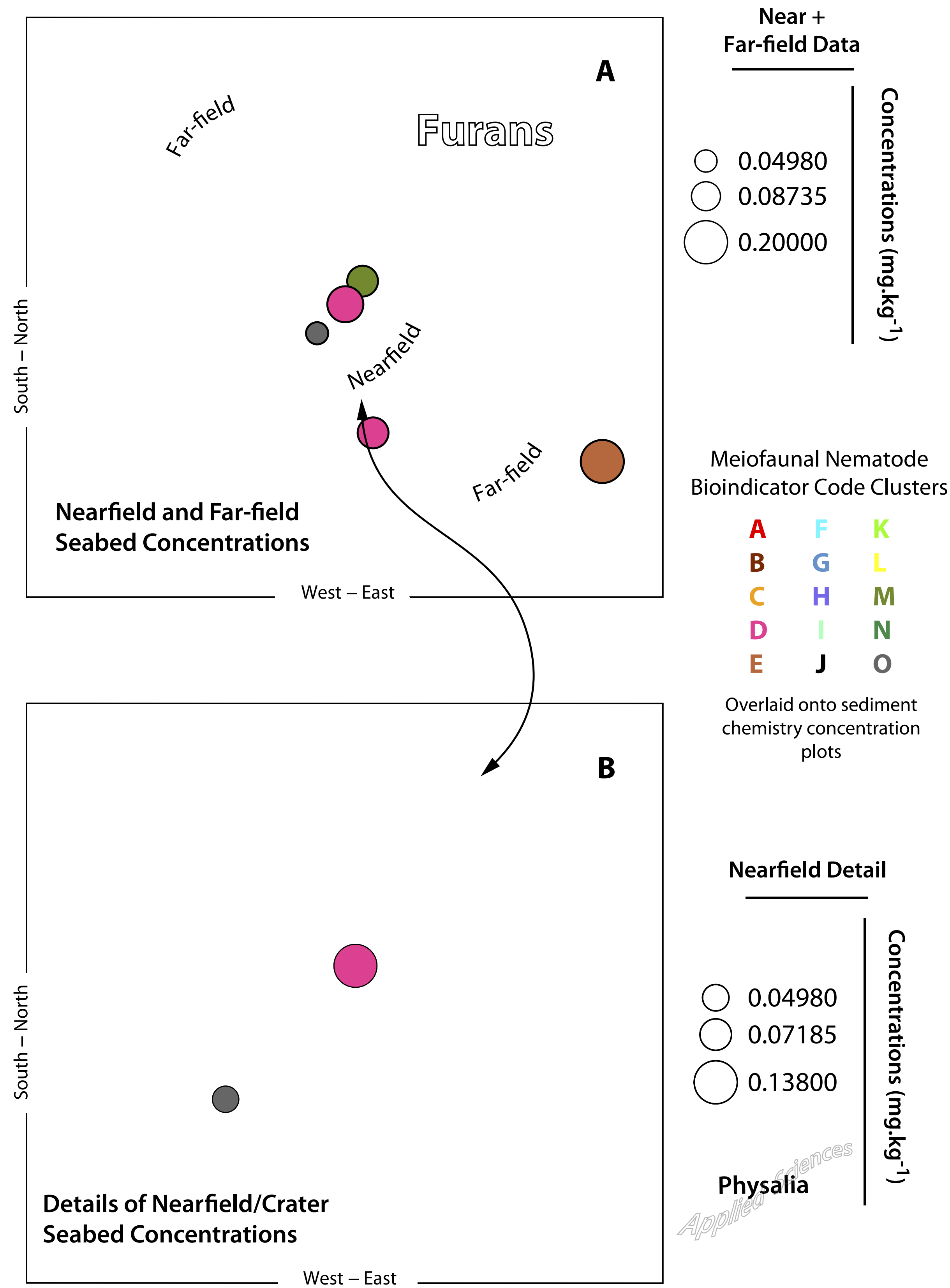

Figure E29. Sediment furan 2,3,7,8-TCDF concentration distributions in the full survey area (A) and in the near-field sampling stations (B). Although fewer detects of this furan were found than in 2,3,4,7,8-PCDF (Figure E28), the spatial distribution of 2,3,7,8-TCDF exhibited strong similarities with the former compound.

Σ Aliphatics and Aromatics (C5 - C35)

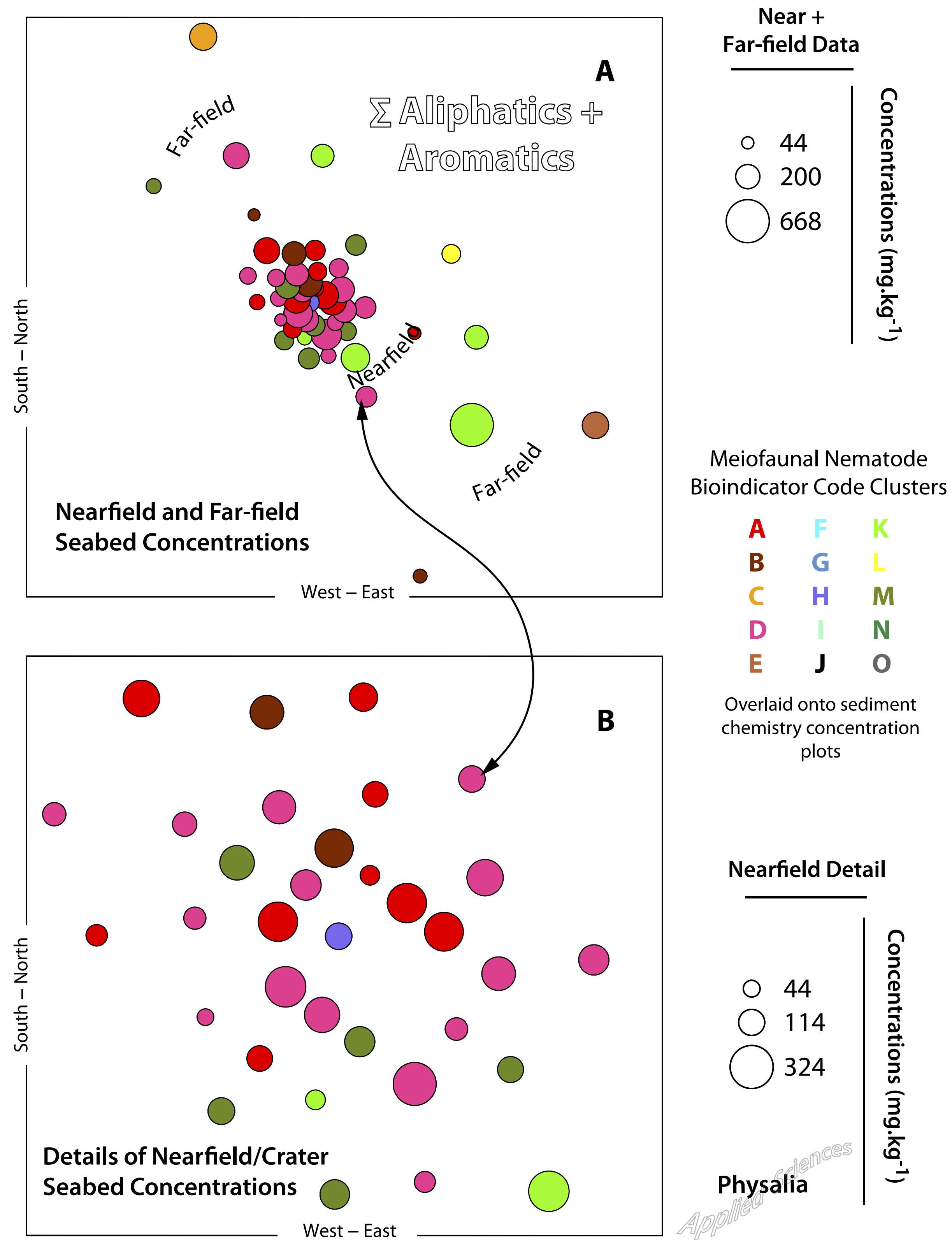

Figure E30. Sum total of the aliphatic/aromatic organic compounds present in the sediments of the survey near- and far-field survey area. Note that, despite 4 years since the blow-out incident, concentrations of these wide-spread organic compounds have remained depleted in the crater sediments. This is consistent with an active, on-going process that elutes materials from the blow-out crater and prevents in-filling with fine, detrital and sedimentary materials.

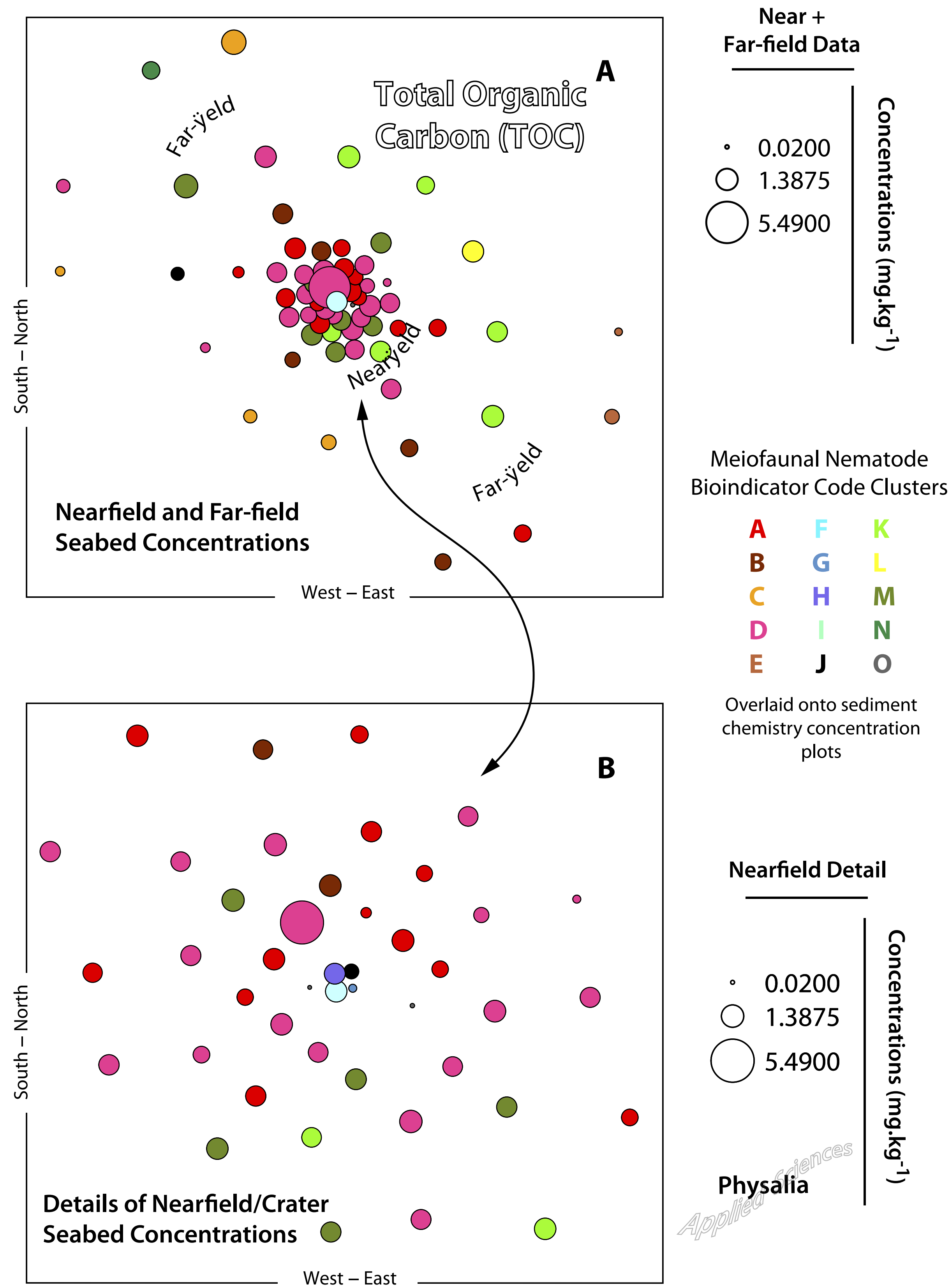

Figure E31. Total organic carbon (TOC) values in the nearÿeld (A) and farÿeld (B) sites. Note the elevated sediment TOC value present within the crater zone located immediately adjacent to the reduced and below detection limits values recorded in the persistent, deeper (ca. 40 m) incident blow-out pit.

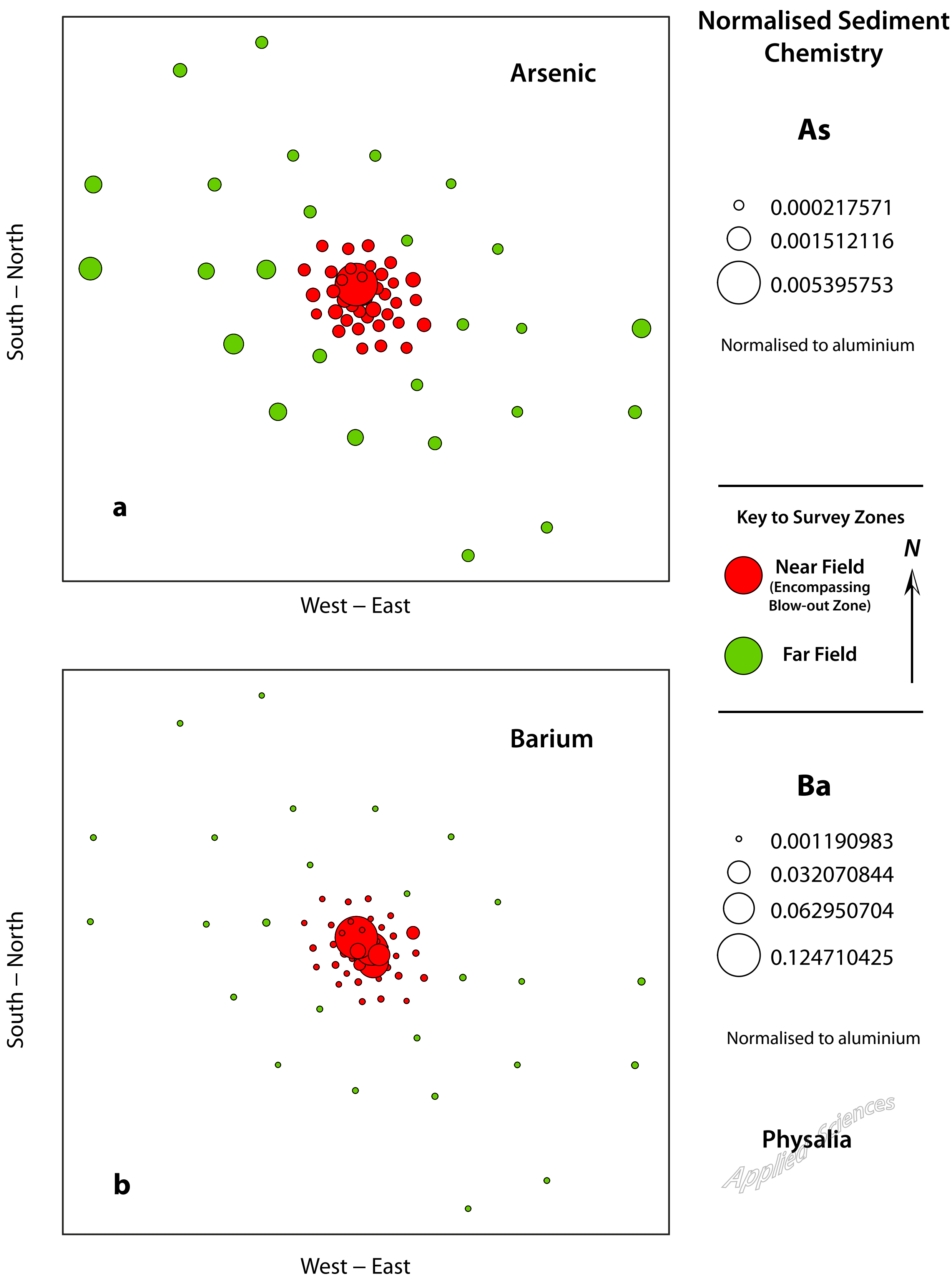

Figure E32. Distributions of seabed concentrations of (a) **arsenic** and (b) **barium** recorded in the sediment samples collected from the near and far field, offshore sampling stations during the Physalia January - February 2016 survey of the *KS Endeavor* blow-out site.

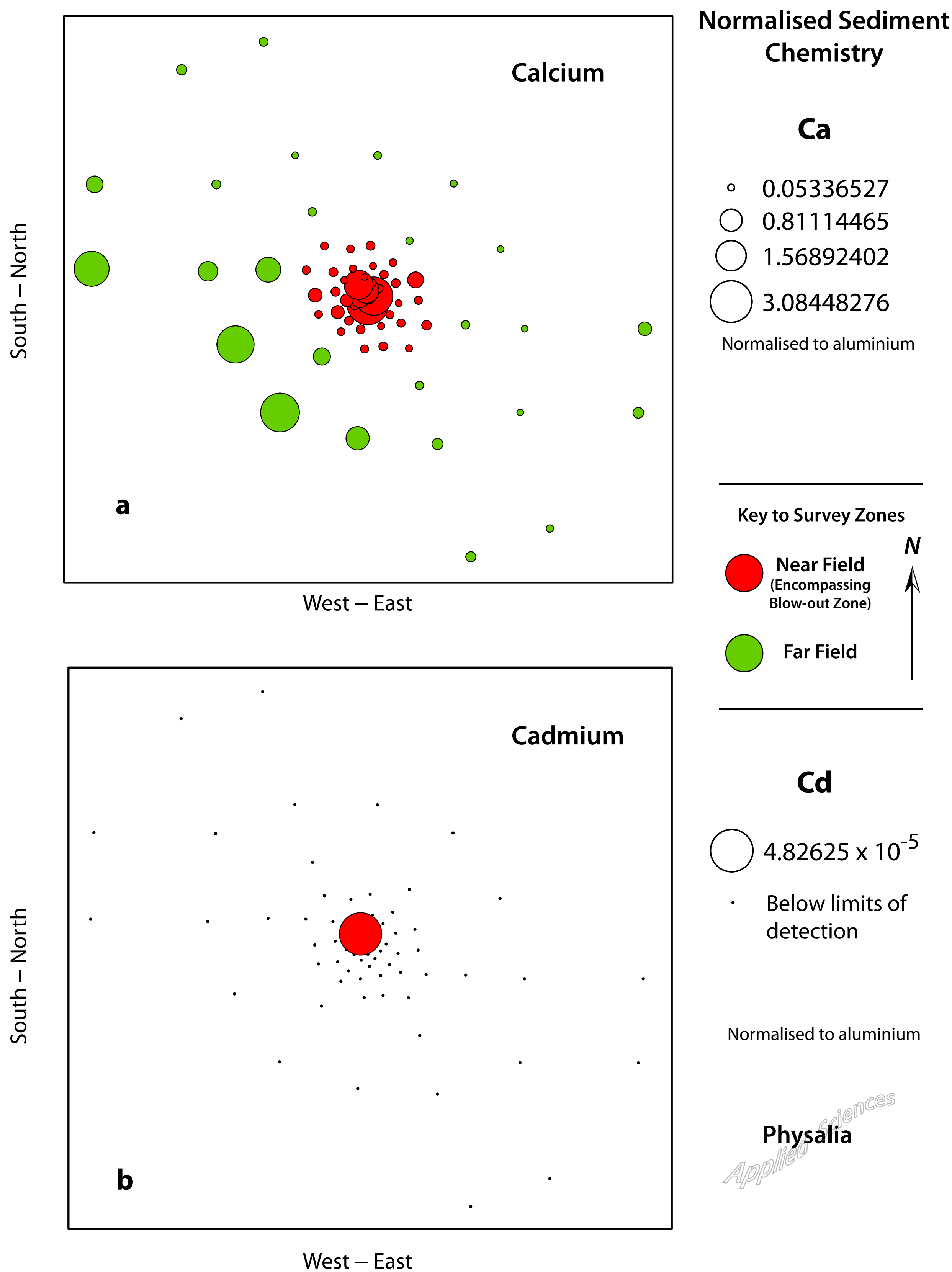

Figure E33. Distributions of seabed concentrations of (a) **calcium** and (b) **cadmium** recorded in the sediment samples collected from the near and far field, offshore sampling stations during the Physalia January - February 2016 survey of the *KS Endeavor* blow-out site.

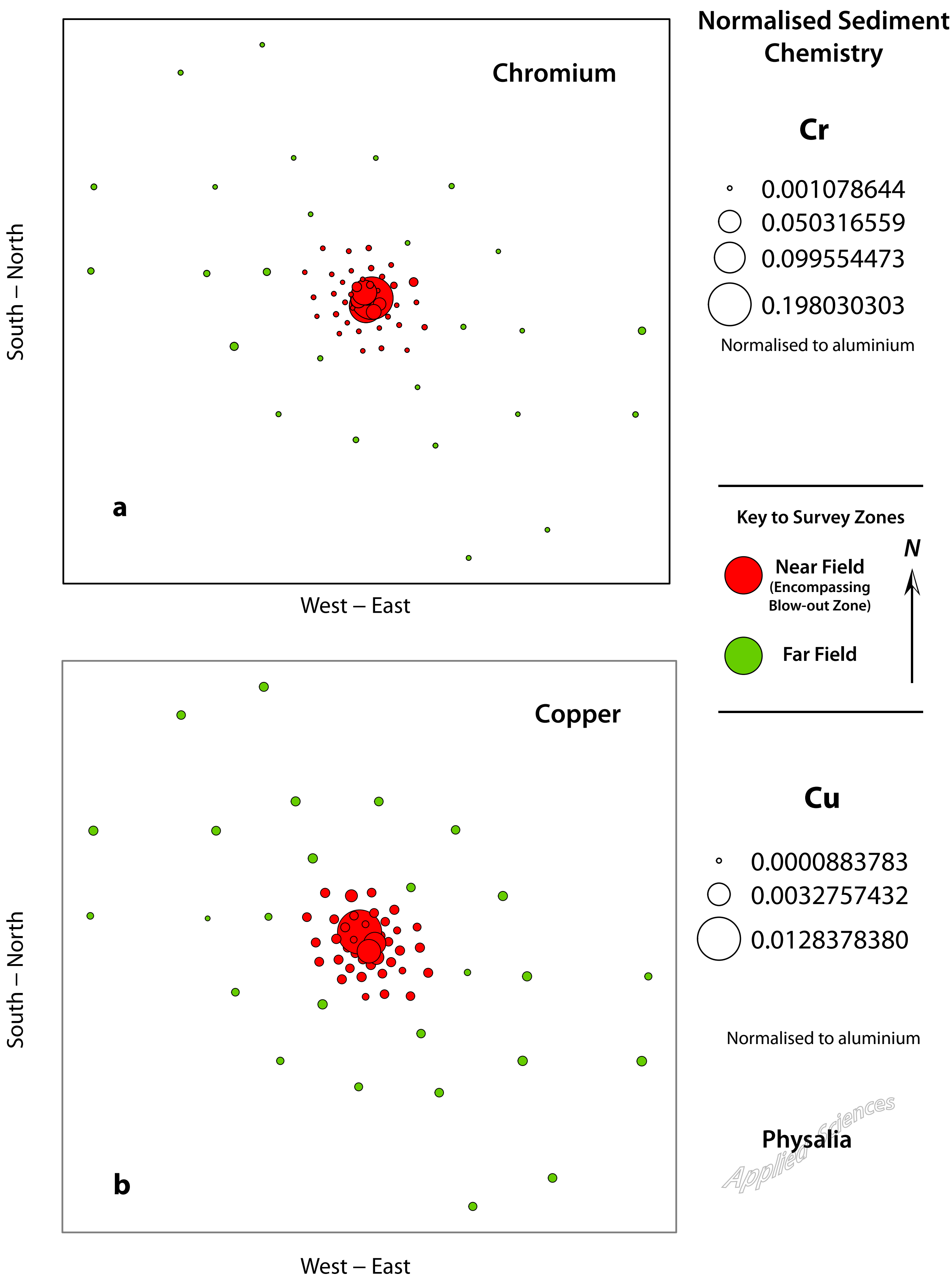

Figure E34. Distributions of seabed concentrations of (a) **chromium** and (b) copper recorded in the sediment samples collected from the near and far field, offshore sampling stations during the Physalia January - February 2016 survey of the *KS Endeavor* blow-out site.

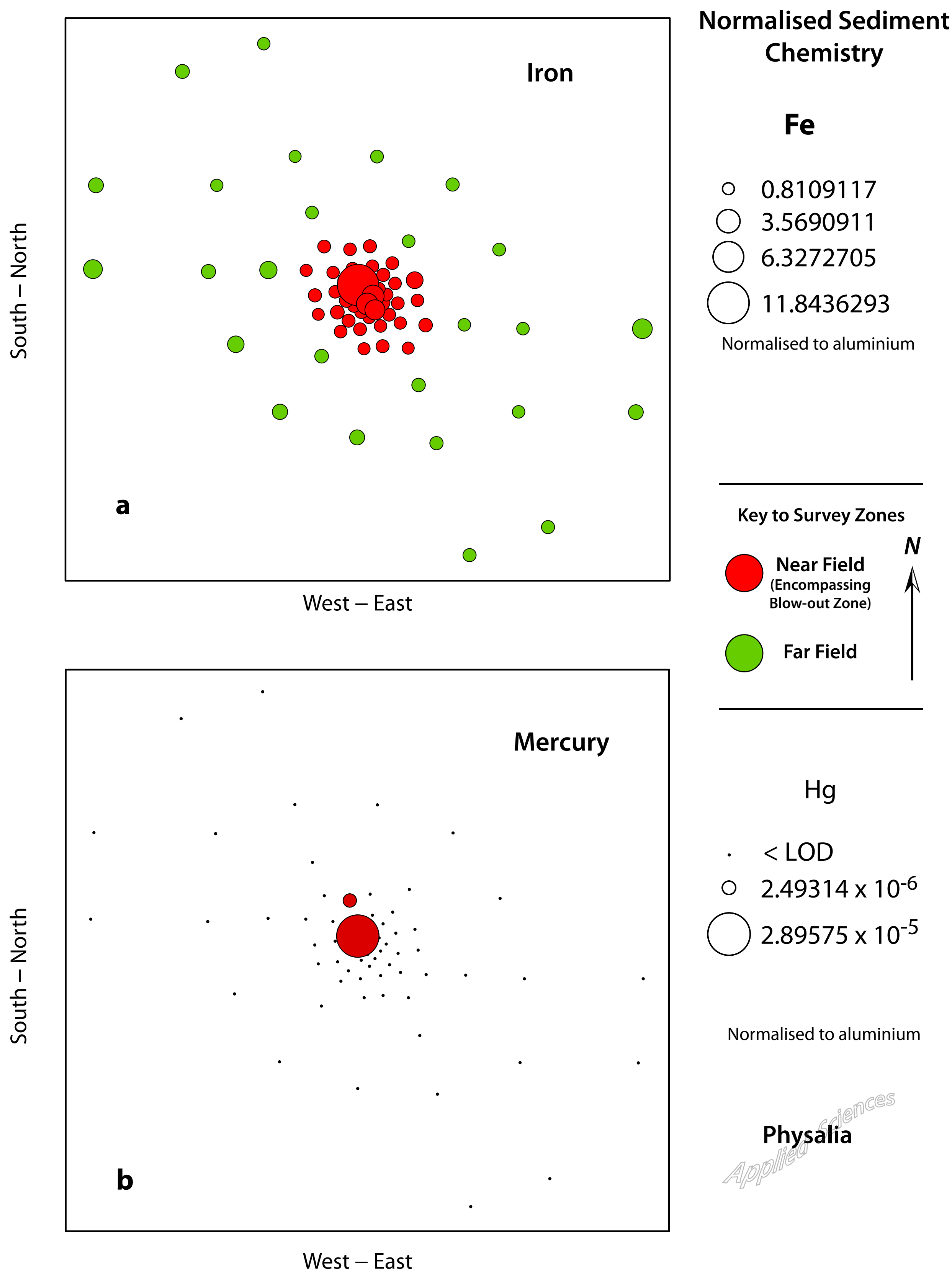

Figure E35 . Distributions of seabed concentrations of (a) **iron** and (b) **mercury** recorded in the sediment samples collected from the near and far field, offshore sampling stations during the Physalia January - February 2016 survey of the *KS Endeavor* blow-out site.

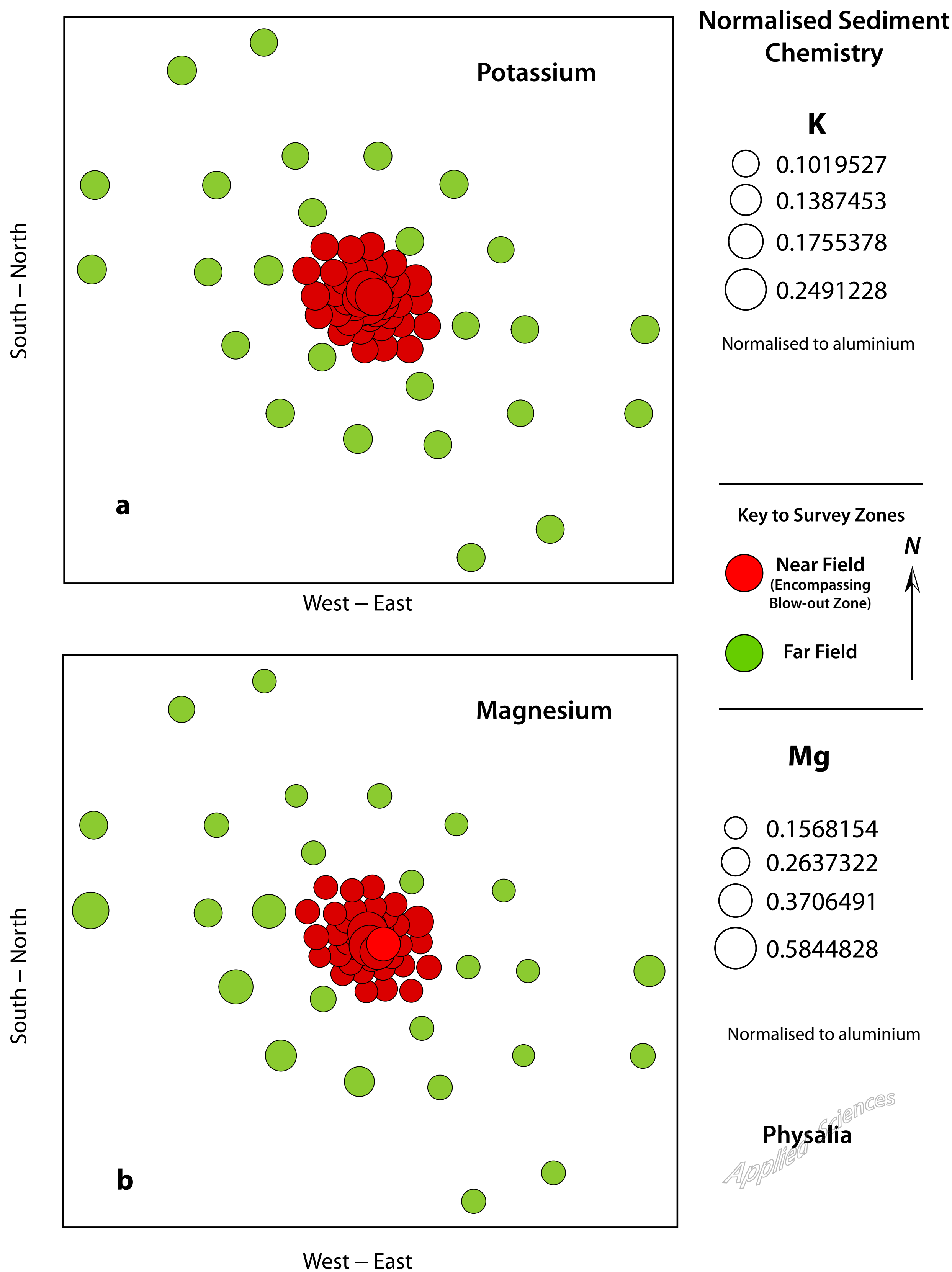

Figure E36. Distributions of seabed concentrations of (a) **potassium** and (b) **magnesium** recorded in the sediment samples collected from the near and far field, offshore sampling stations during the Physalia January - February 2016 survey of the *KS Endeavor* blow-out site.

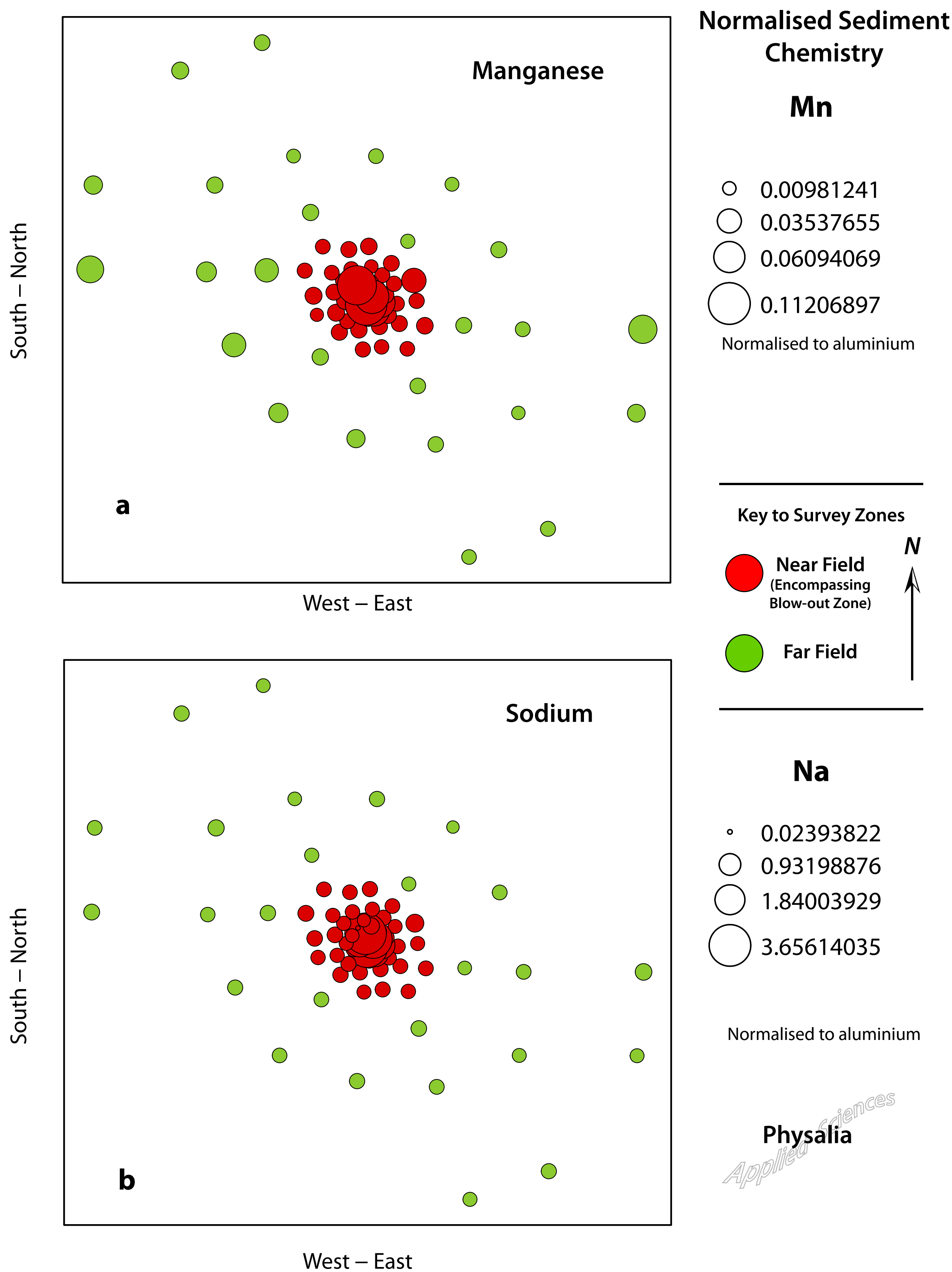

Figure E37. Distributions of seabed concentrations of (a) **manganese** and (b) **sodium** recorded in the sediment samples collected from the near and far field, offshore sampling stations during the Physalia January - February 2016 survey of the *KS Endeavor* blow-out site.

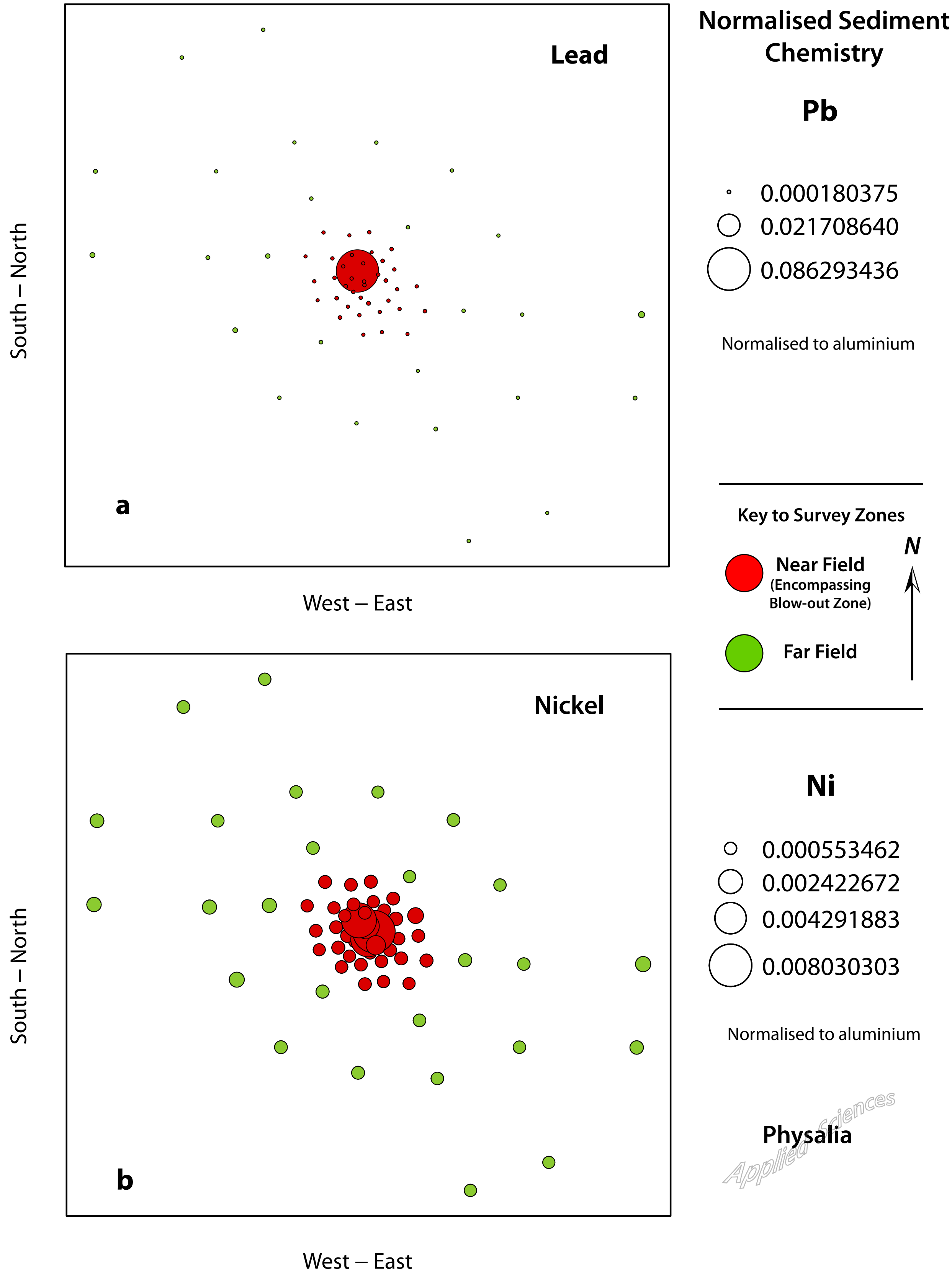

Figure E38. Distributions of seabed concentrations of (a) **nickel** and (b) **lead** recorded in the sediment samples collected from the near and far field, offshore sampling stations during the Physalia January - February 2016 survey of the *KS Endeavor* blow-out site.

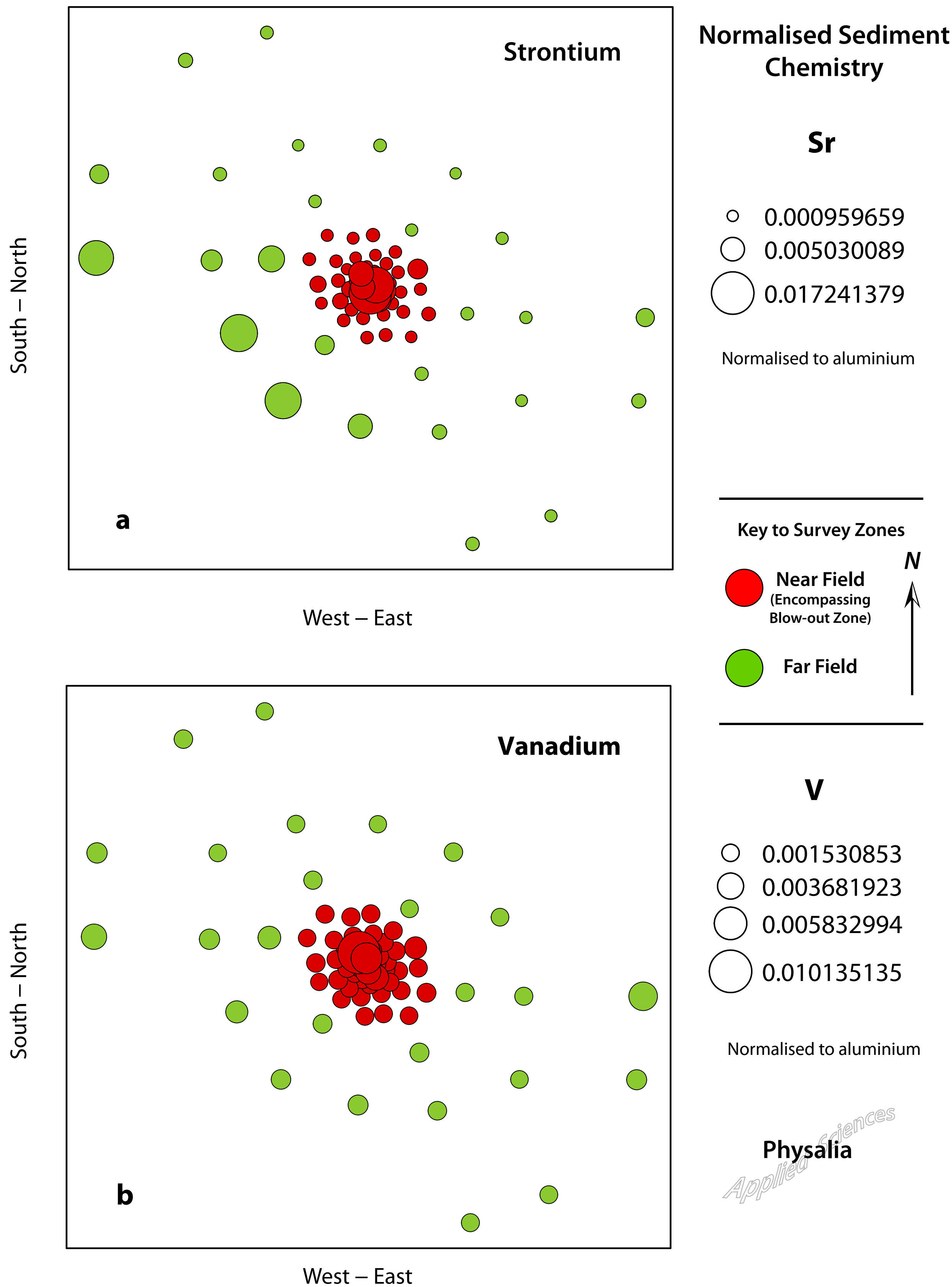

Figure E39. Distributions of seabed concentrations of (a) **strontium** and (b) **vanadium** recorded in the sediment samples collected from the near and far field, offshore sampling stations during the Physalia January - February 2016 survey of the *KS Endeavor* blow-out site.

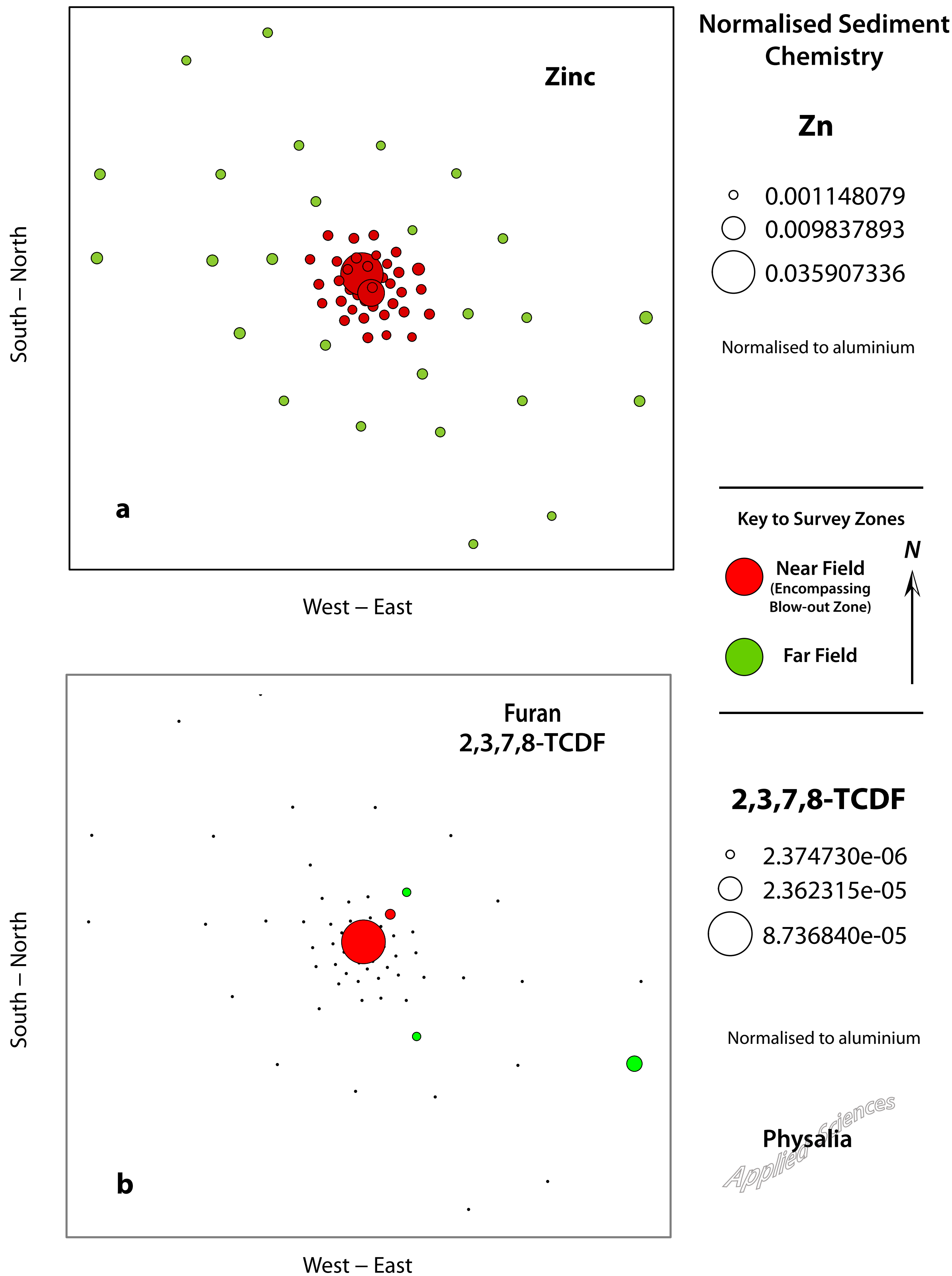

Figure E40. Distributions of concentrations of (a) **zinc** and (b) **Furan 2,3,7,8-TCDF** recorded in the sediment samples collected from the near and far field, offshore sampling stations during the Physalia January - February 2016 survey of the *KS Endeavor* blow-out site.

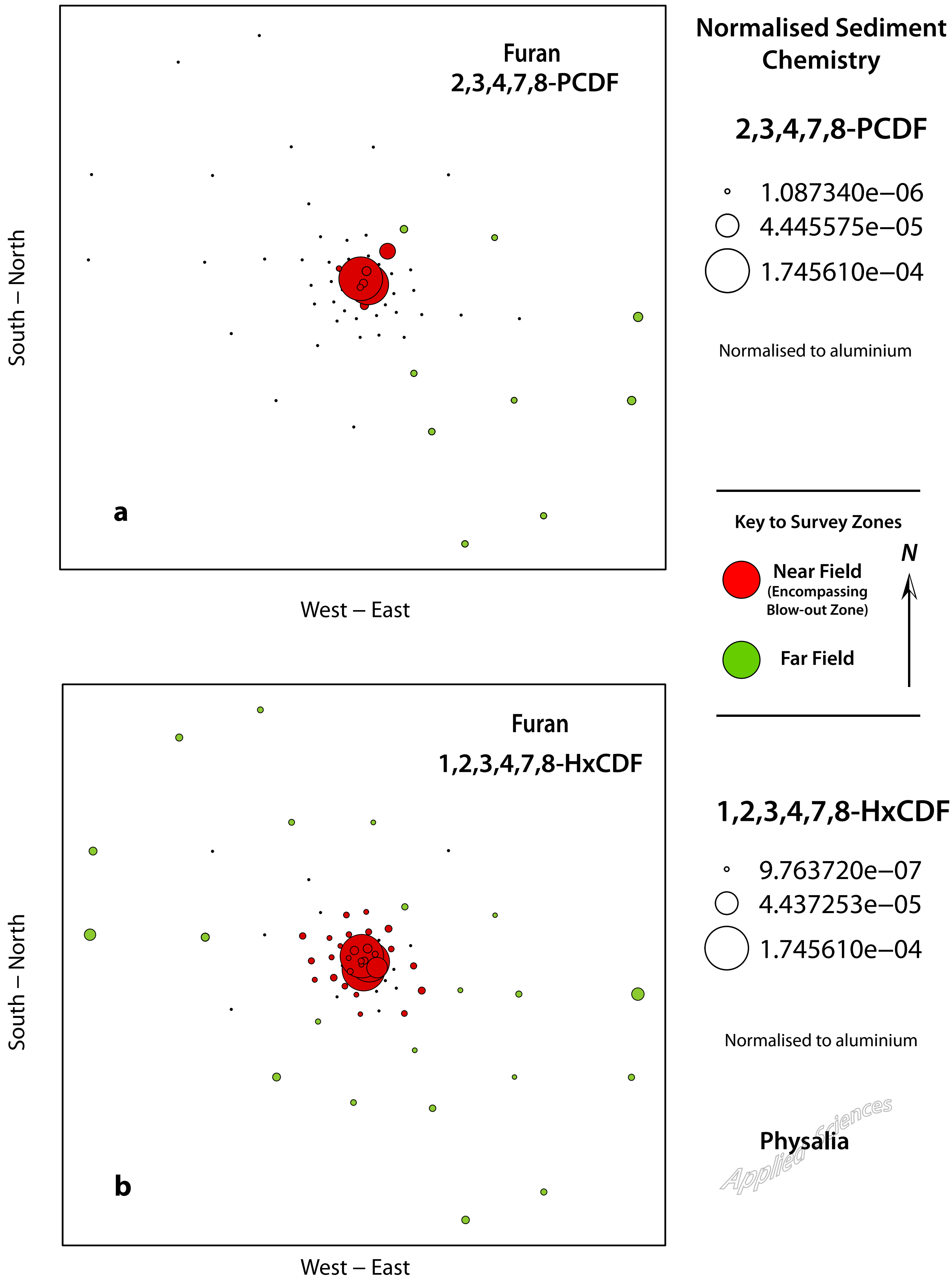

Figure E41. Concentration distributions of (a) **2,3,4,7,8-PCDF** and (b) **1,2,3,47,8-PCDF** recorded n the samples collected from the near and far field, offshore sampling sites stations during the Physalia 2016 survey of the *KS Endeavor* blow-out site.

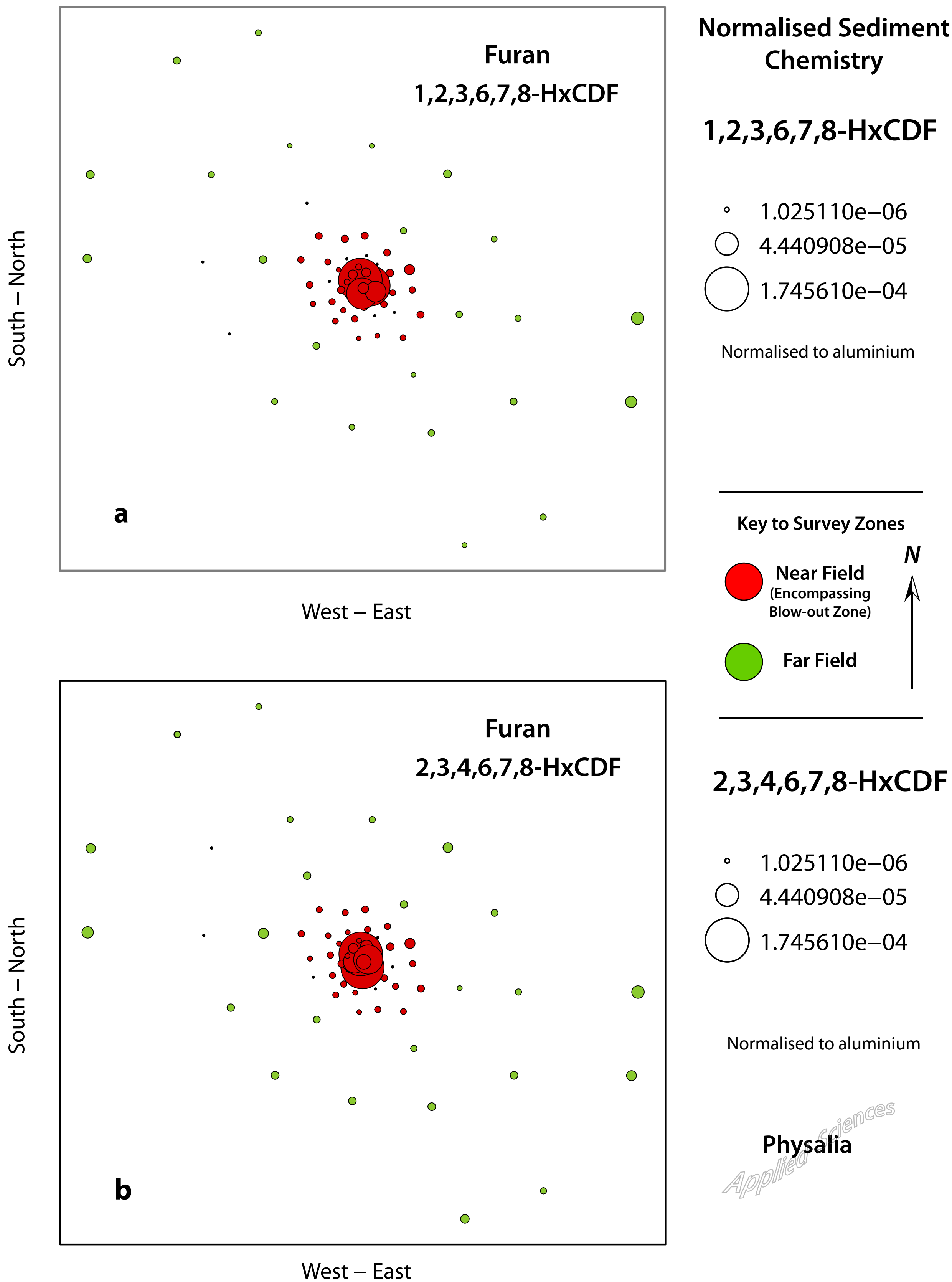

Figure E42. Concentration distributions of (a) **1,2,3,6,7,8-HxCDF** and (b) **2,3,4,6,7,8-HxCDF** recorded in the samples collected from the near and far field, offshore sampling sites stations during the Physalia 2016 survey of the *KS Endeavor* blow-out site.

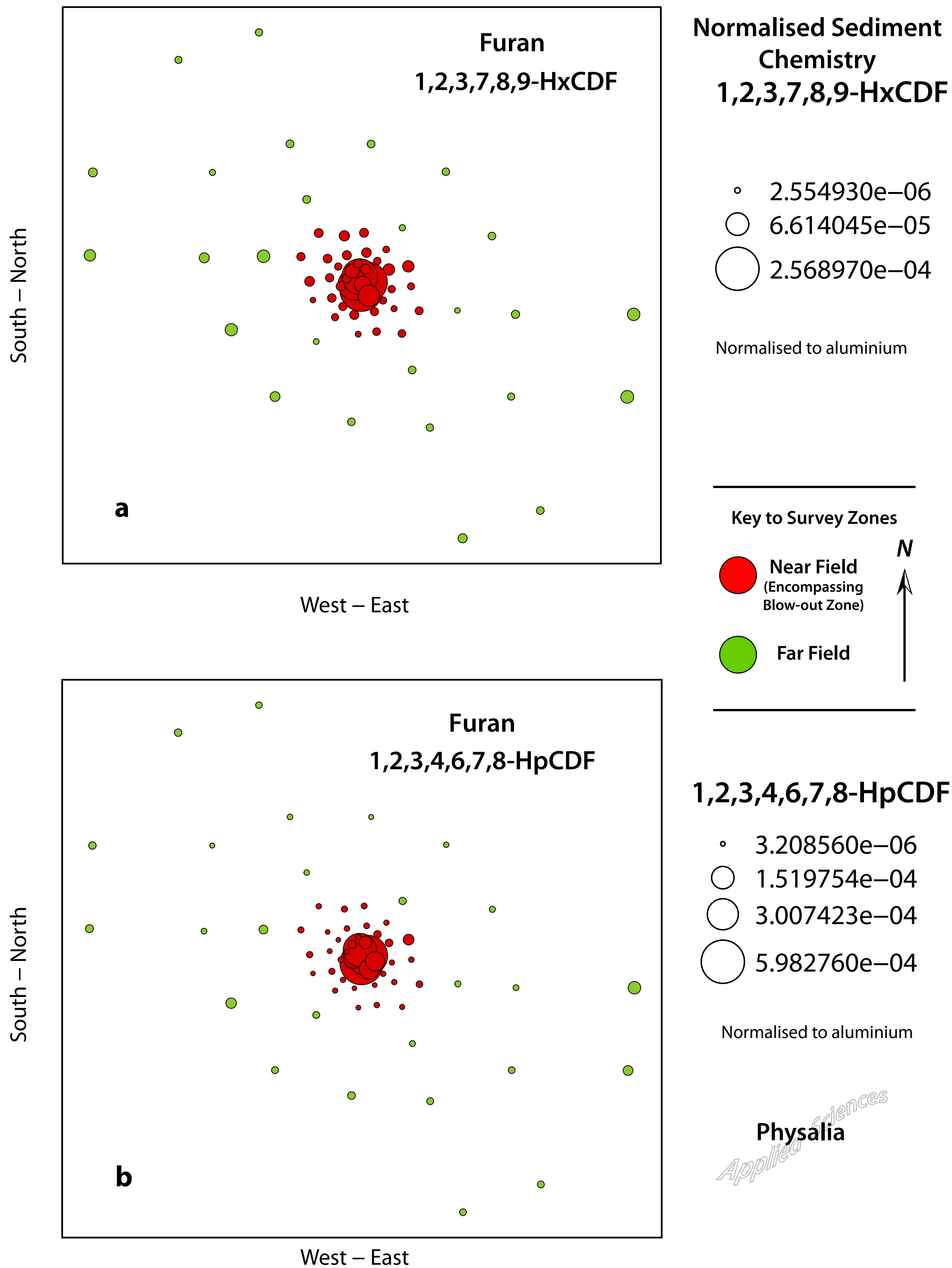

Figure E43. Concentration distributions of (a) **1,2,3,7,8,9-HxCDF** and (b) **1,2,3,4,6,7,8 HpCDF** recorded in the samples collected from the near and far field, offshore sampling sites stations during the Physalia 2016 survey of the *KS Endeavor* blow-out site.

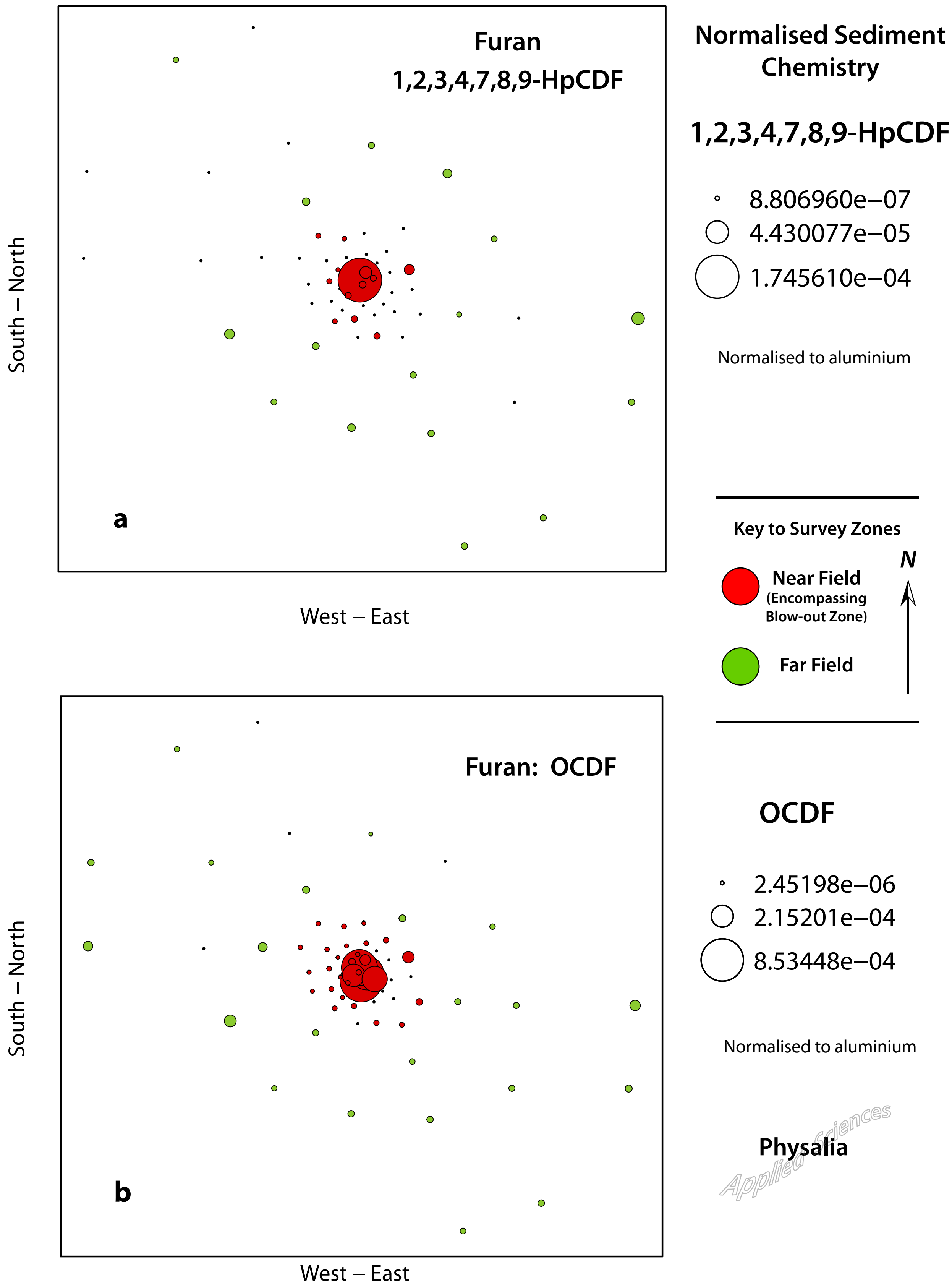

Figure 44. Concentration distributions of (a) **1,2,3,4,7,8,9-HpCDF** and (b) **OCDF** recorded in the samples collected from the near and far field, offshore sampling sites stations during the Physalia 2016 survey of the *KS Endeavor* blow-out site.

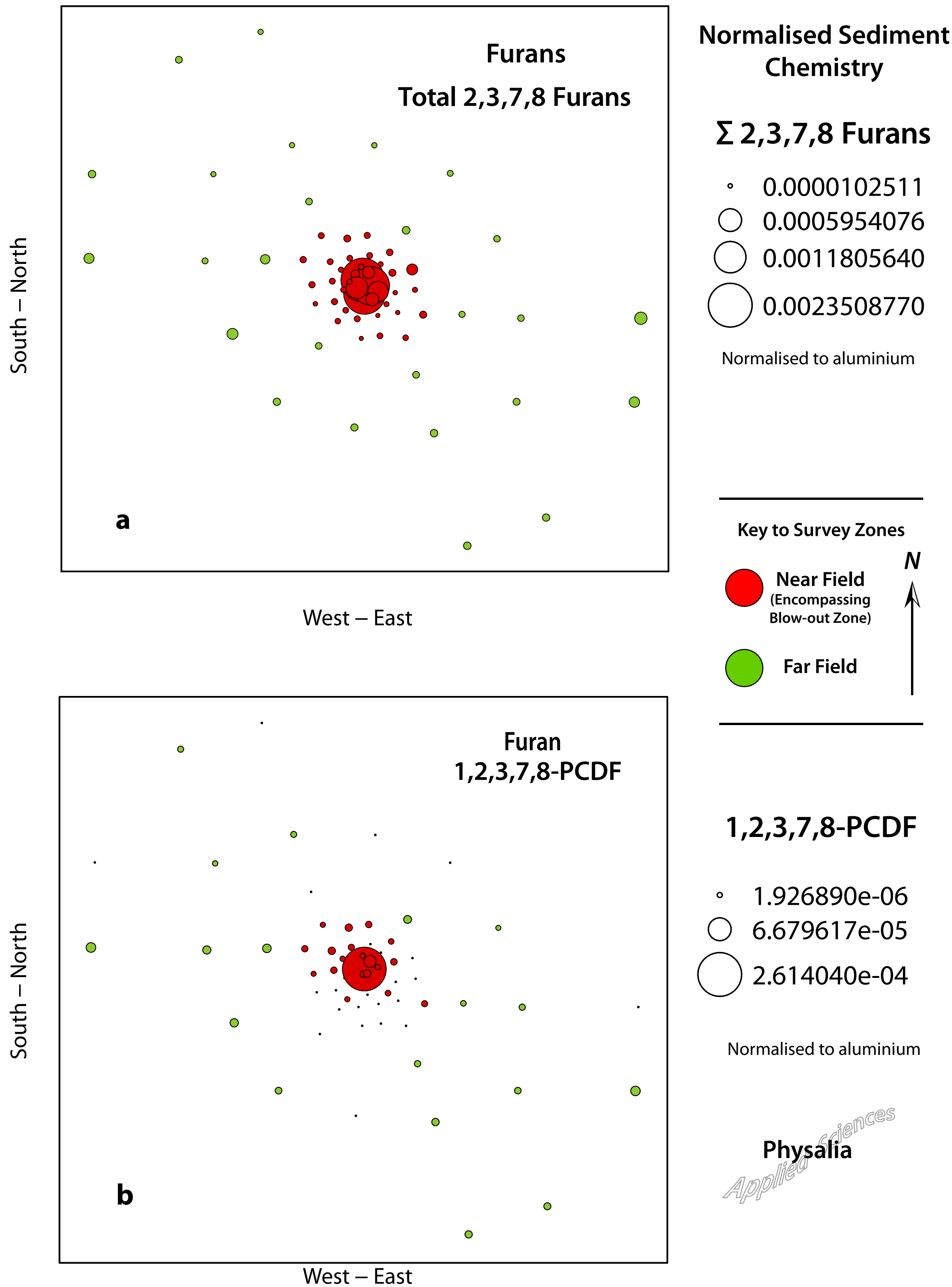

Figure 45. Concentration distributions of (a) **total 2,3,7,8 Furans** and (b) **1,2,3,4,7,8 PCDF** recorded in the samples collected from the near and far ÿeld, o˛ shore sampling sites stations during the Physalia 2016 survey of the *KS Endeavor* blow-out site.

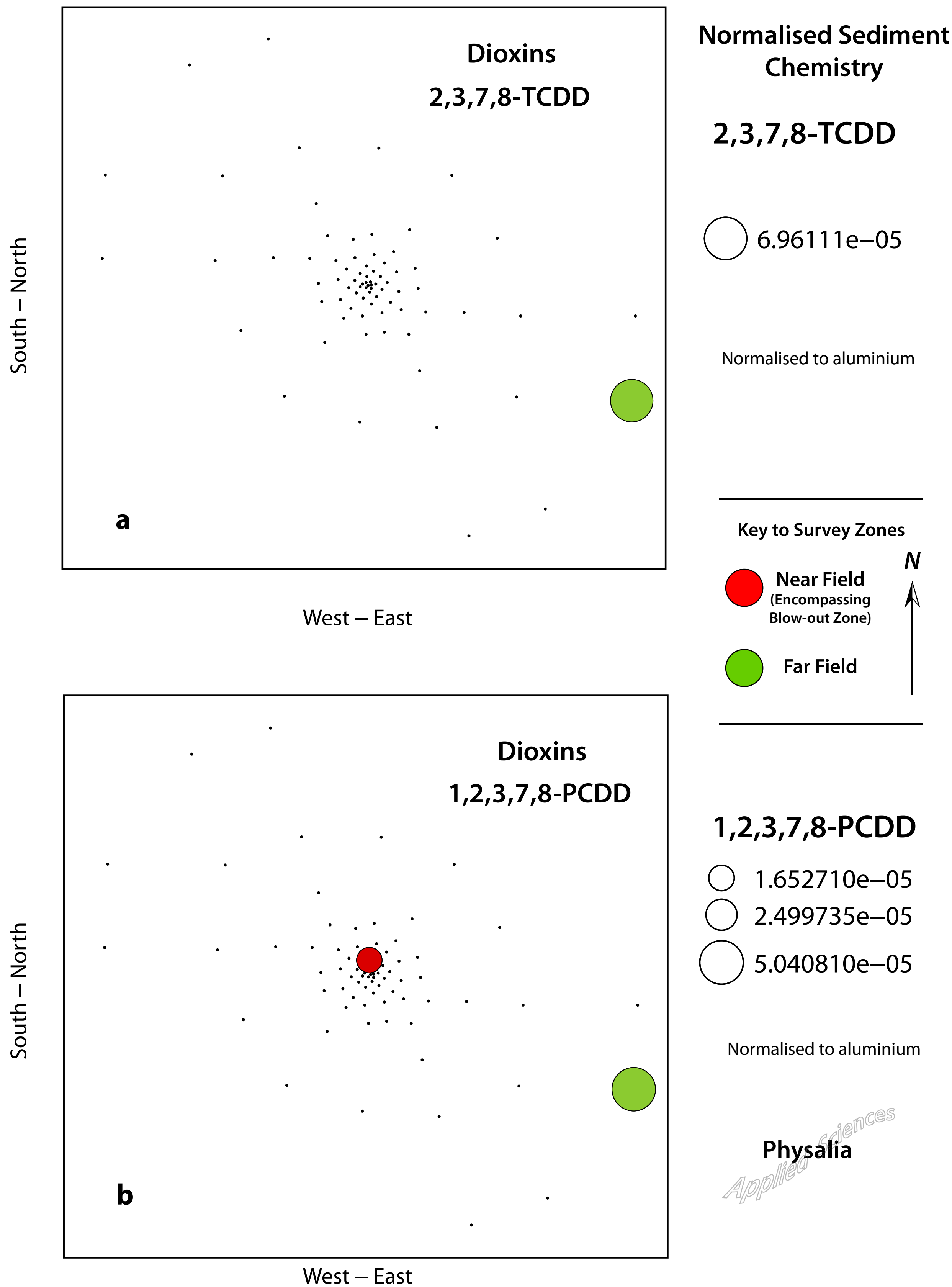

Figure 46. Concentration distributions of dioxins (a) **2,3,7,8-TCDD** and (b) **1,2,3,7,8-PCDD** recorded in the samples collected from the near and far field, offshore sampling sites stations during the Physalia 2016 survey of the *KS Endeavor* blow-out site.

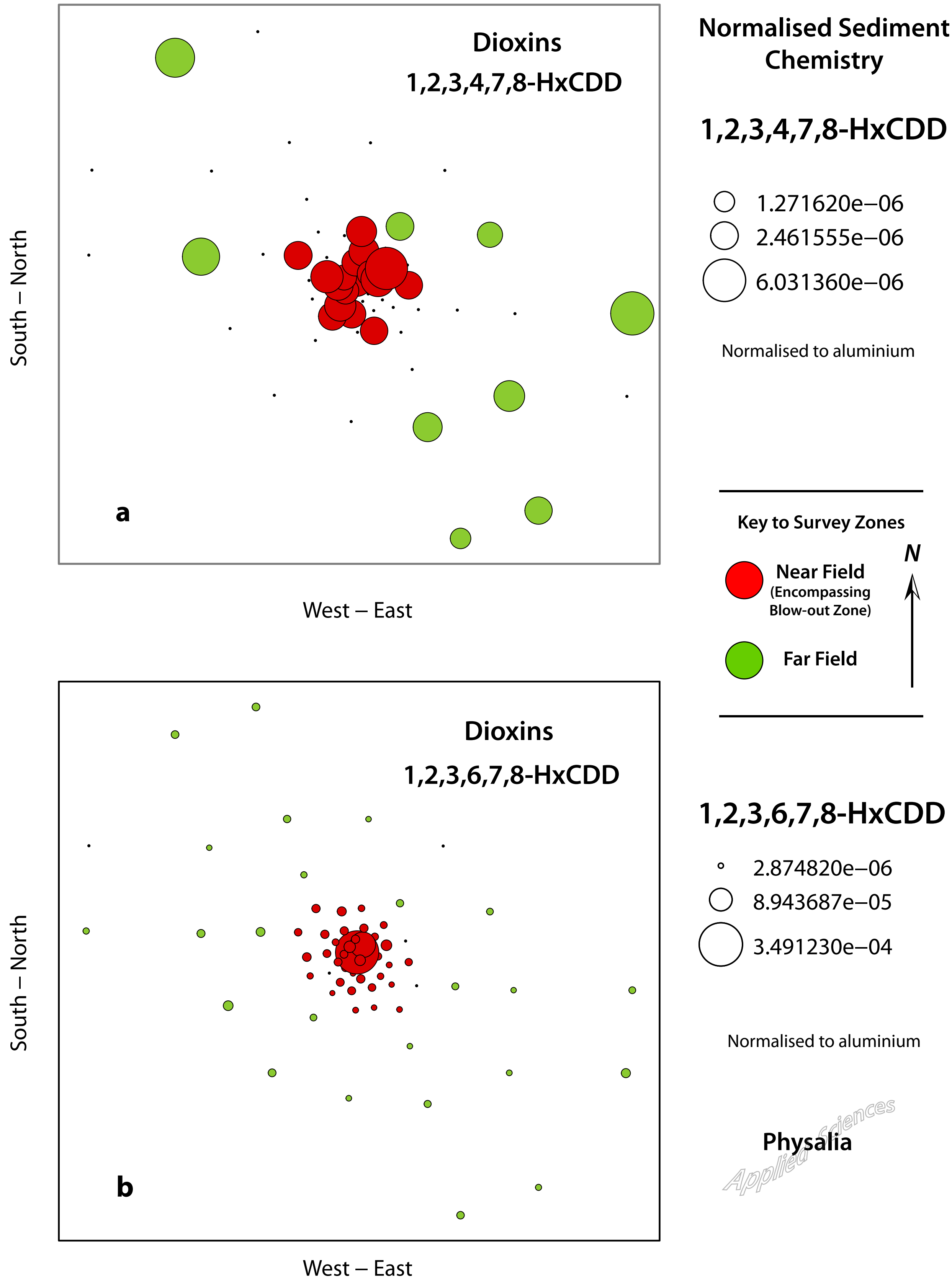

Figure 47. Concentration distributions of dioxins (a) **1,2,3,4,7,8-HxCDD** and (b) **1,2,3,6,7,8-HxCDD**recorded in the samples collected from the near and far field, offshore sampling sites stations during the Physalia 2016 survey of the *KS Endeavor* blow-out site.

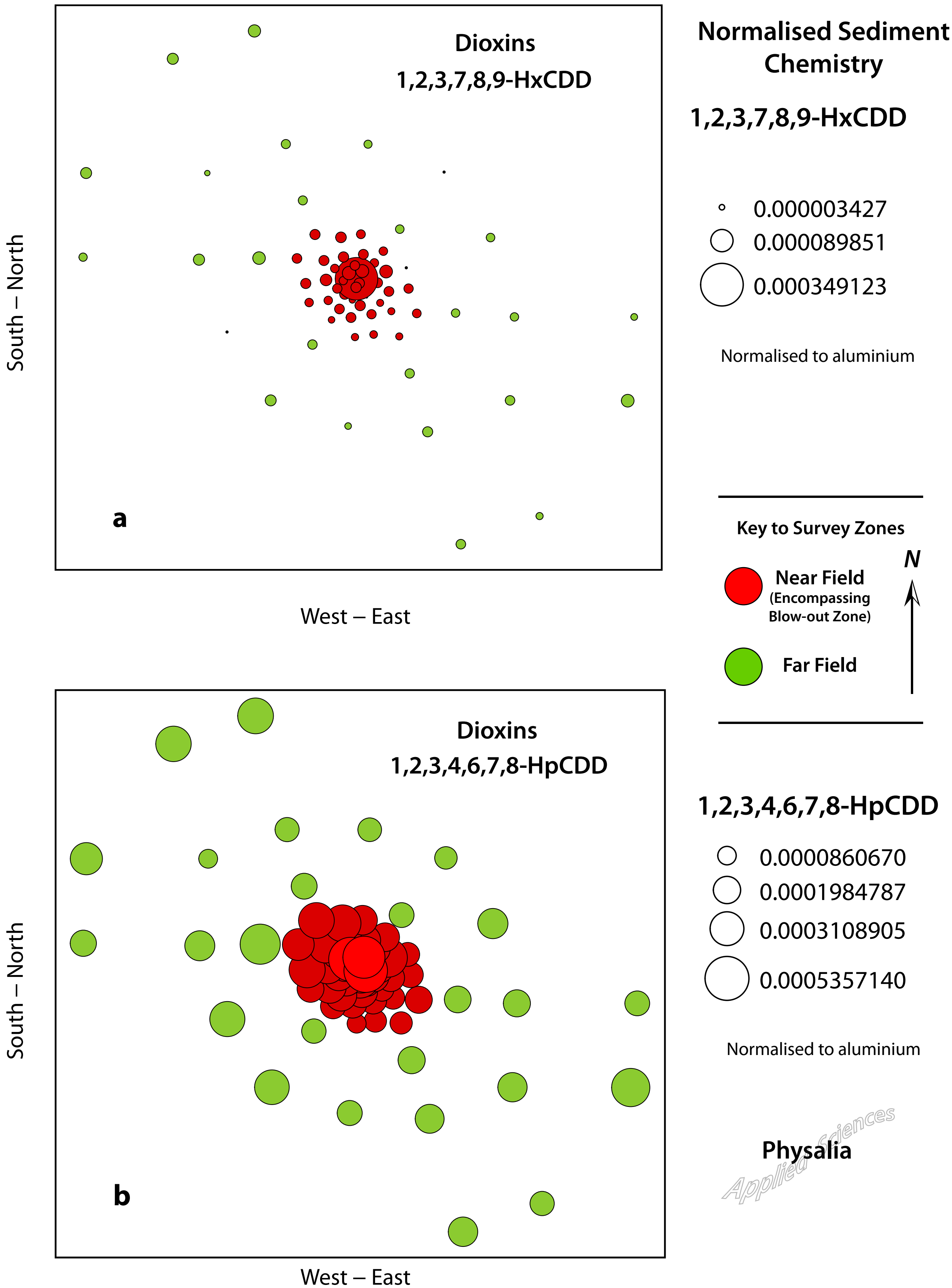

Figure 48. Dioxin concentration distributions of (a) 1**,2,3,7,8,9-HxCDD** and (b) **1,2,3,4,6,7,8-HpCDD**recorded in the samples collected from the near and far field, offshore sampling sites stations during the Physalia 2016 survey of the *KS Endeavor* blow-out site.

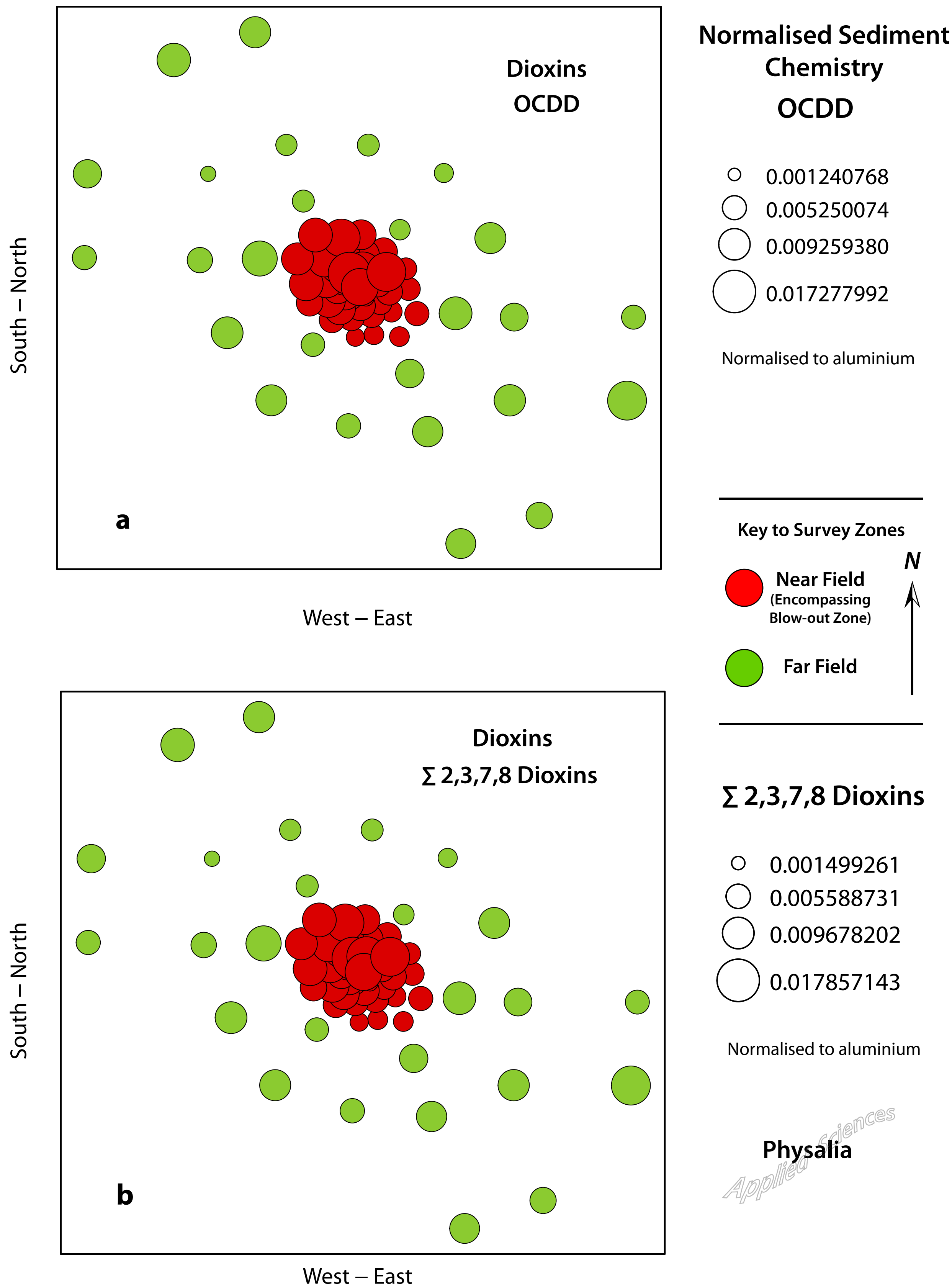

Figure 49. Concentration distributions of dioxins (a) **OCDD** and (b) total **2,3,7,8 Dioxins** recorded in the samples collected from the near and far field, offshore sampling sites stations during the Physalia 2016 survey of the *KS Endeavor* blow-out site.

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Appendix F

Interactions between the Survey Area Sediment Physico-chemical Factors and the Faunal Community Structures

Physalia

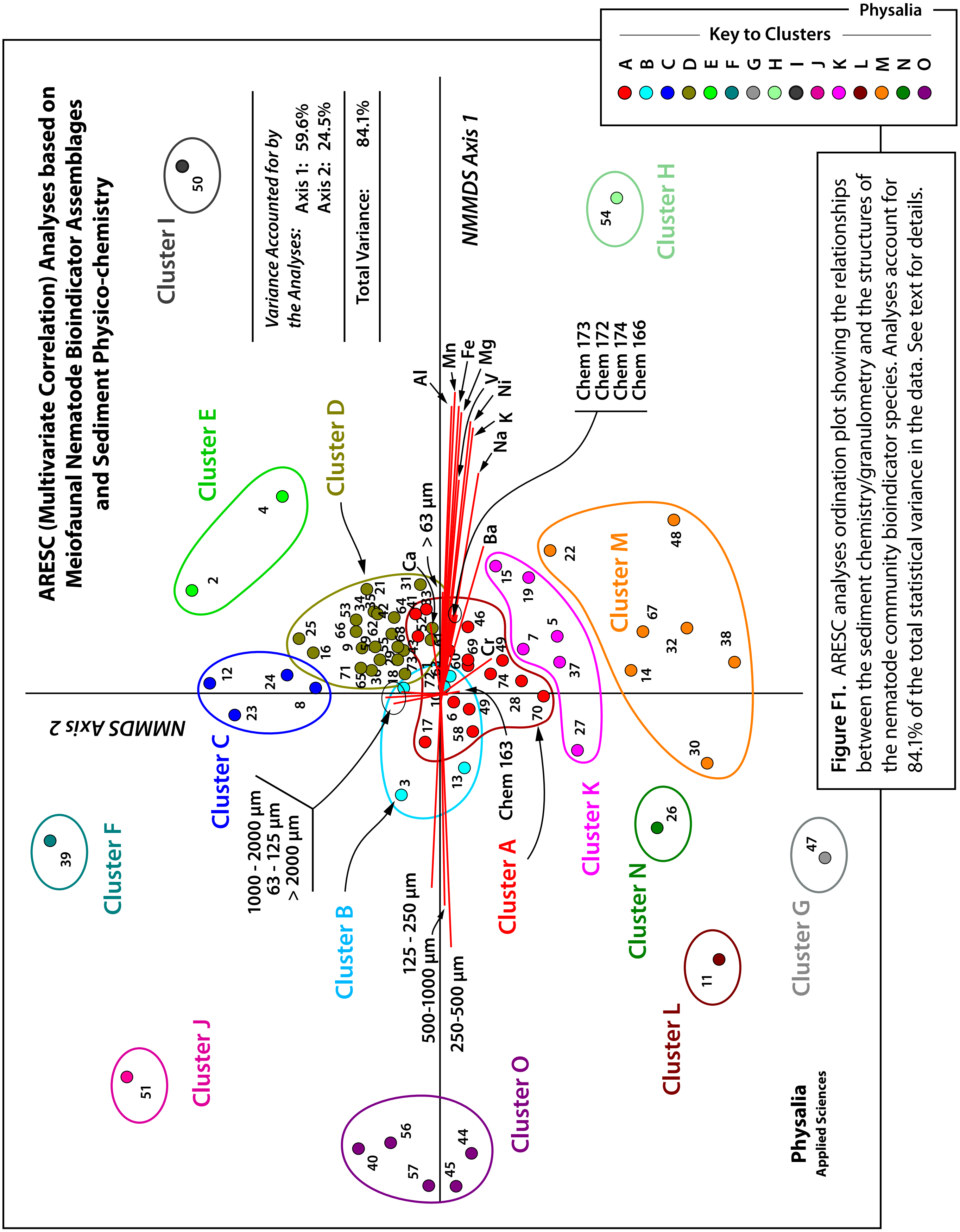

Figure F1. ARESC analyses ordination plot showing the relationships between the sediment chemistry/granulometry and the structures of the nematode community bioindicator species. Analyses account for 84.1% of the total statistical variance in the data. See text for details.

Sediment Determinands	ARESC Axis 1		Sediment Determinands	ARESC Axis 2
Manganese Mn	**0.737**		**Particle Size Fraction 63 - 125 µm**	**0.315**
Iron Fe	**0.719**	α < 0.01	**Chromium Cr**	**-0.300**
Vanadium V	**0.719**		**Particle Size Fraction 1,000 - 2,000 µm**	**0.288**
Magnesium Mg	**0.715**		**Sodium Na**	**-0.275**
Aluminium Al	**0.700**		**Particle Size Fraction > 2000 µm**	**0.265**
Potassium K	**0.693**		**Nickel Ni**	**-0.259**
Particle Size Fraction 250 - 500 µm	**-0.672**		**Potassium K**	**-0.239**
Nickel Ni	**0.641**		Aluminium Al	-0.231
< 63 µm	**0.621**		Magnesium Mg	-0.186
Particle Size Fraction 500 -1,000 µm	**-0.616**		Particle Size Fraction < 63 µm	-0.180
Particle Size Fraction 125 - 250 µm	**-0.589**	α < 0.05	Vanadium V	-0.178
Sodium Na	**0.517**		Furan 1,2,3,4,6,7,8-HpCDF	-0.165
Barium Ba	**0.428**		Total Organic Carbon (TOC)	-0.158
Dioxin 1,2,3,4,6,7,8-HpCDD	**0.395**		Manganese Mn	-0.157
∑ 2,3,7,8-Dioxins	**0.380**		Dioxin 1,2,3,4,6,7,8-HpCDD	-0.156
Dioxin OCDD	**0.378**		Iron Fe	-0.155
Total Organic Carbon (TOC)	**0.371**		∑ 2,3,7,8-Dioxins	-0.141
Calcium Ca	**0.354**		Dioxin OCDD	-0.140
Chromium Cr	**0.254**		Calcium Ca	0.133
Particle Size Fraction 1,000 - 2,000 µm	-0.126		Particle Fraction 125 - 250 µm	0.123
Particle Size Fraction 63 - 125 µm	-0.036		∑ 2,3,7,8-Furans	-0.106
∑ 2,3,7,8-Furans	0.031		Barium Ba	-0.084
Particle Size Fraction > 2000 µm	-0.018		Particle Fraction 250 - 500 µm	-0.042
Furan 1,2,3,4,6,7,8-HpCDF	-0.014		Particle Fraction 500 -1,000 µm	-0.001

Table F1. Multivariate correlation (ARESC) analyses based on Pearson's correlation coefficients, identifying and ranking the relationships between the measured marine physico-chemical parameters and the structures of the marine nematode bioindicator communities (i.e. the factors that determine which species occur at each site and their relative abundances). Factors highlighted in **RED** are strongly statistically significantly associated with the structures of the meiofaunal assemblages at the level $\alpha = 0.01$ (i.e. ***less than 1 time in 100 would the sediment physico-chemical factors relationships not be associated with the structures of the communities***) and factors highlighted in **ORANGE** are statistically significantly correlated with the nemtode community structures at the level $\alpha = 0.05$ (i.e. ***less than 5 times in 100 would the sediment physico-chemical factors relationships not be associated with the structures of the communities***).

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Appendix G

Photographic Plates Relating to Field and Laboratory Work

Physalia

Plate 1: Survey Fieldwork

A. The deck of the survey vessel, *Batoil Beagle I*, showing the wheel house and, to the left, the air conditioned container used by the side scan sonar survey team.

B. The Navy security escort boat that accompanied the *Beagle I* throughout the survey.

C. Deploying the Day grab for collection of benthic sediment samples.

D. Removing samples of sediment from the Day grab for subsequent analyses of physico-chemistry and faunal communities.

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Date: January/February 2016

Physalia

Plate 2: Day Grab Photograph - Site KSE 66

The majority of the sediment samples collected from the survey area away from the immediate vicinity of the former *KS Endeavor* site was characterised by deposits of fine silt. A typical example was the sediment from Site 66, shown here.

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Date: January/February 2016

Physalia

Plate 3: Day Grab Photograph - Site KSE 44

At six sampling sites in and around the seabed crater that existed in the immediate vicinity of the former *KS Endeavor* well head site, the sediment comprised fine, well sorted sand. The silt that characterised much of the survey area was apparently absent from these sites. The example shown here is the sediment retrieved from Site 44, approximately 300 m from the former well head site.

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Date: January/February 2016

Physalia

Plate 4: Day Grab Photograph - Site KSE 42

The sediment retrieved from Site 42, located approximately 625 m from the former *KS Endeavor* well head site, was characterised by a thin layer of sand being present over silt deposits. Similar sand layers overlying silt deposits were observed at five other sites, namely, Sites 43, 52, 58, 62 and 64. All of these sites were within 625 m of the former well head.

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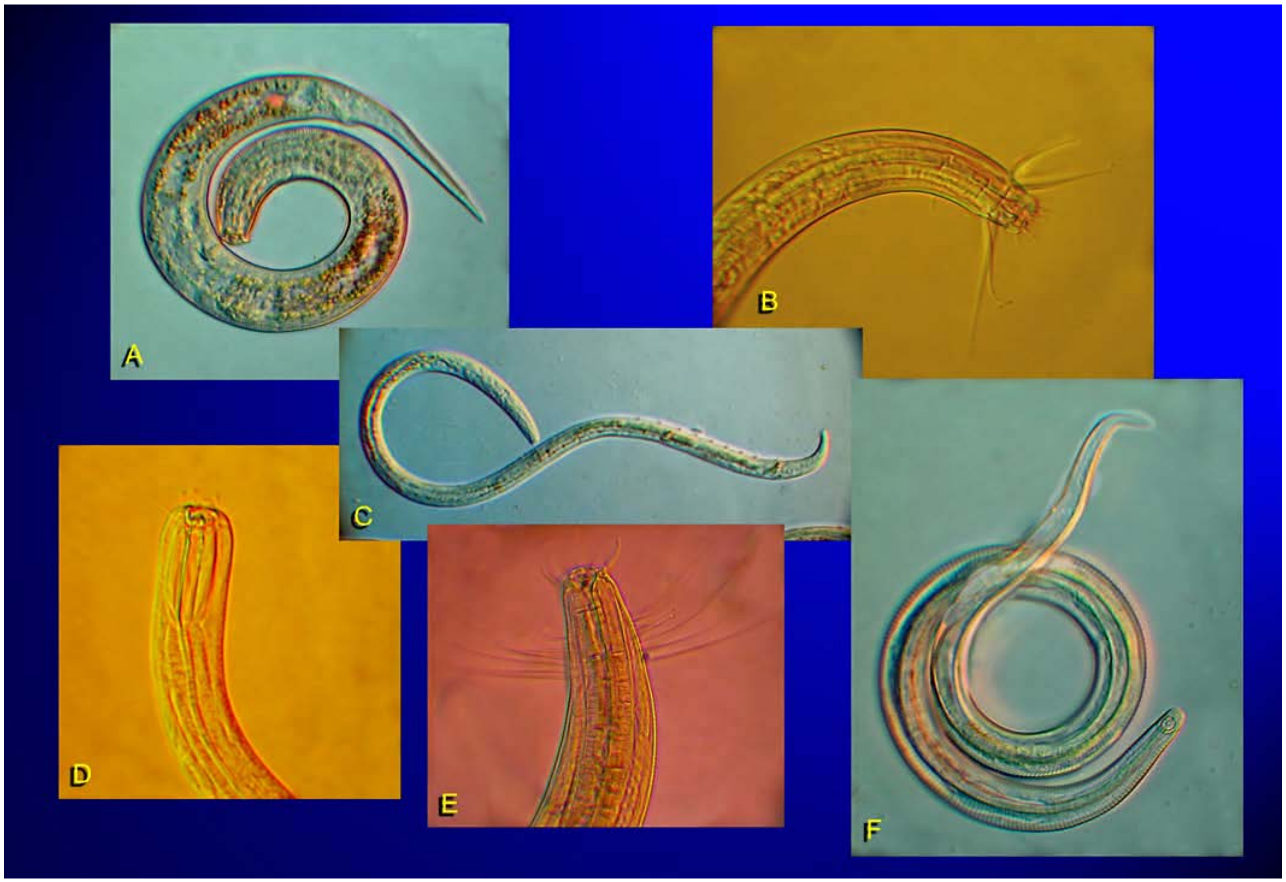
Date: January/February 2016

Physalia

Plate 5: Meiofaunal Nematoda



Examples of meiofaunal nematodes observed in the survey sediments.

A. *Chromaspirina* (code 8). This species occurred regularly in the fine silts.

B. This *Enoplolaimus* species (code 59) occurred in abundance in the sandy sediment at Site 44, near the former KSE well head site.

C. *Comesa cuanensis* (code 15) was one of the most common nematodes in the fine silts.

D. An distinctive but unascribed species, characterised by a deep parallel well-armed mouth, believed to be an Ethmolaimid species

E. *Pseudosteineria* (code 120) with distinctive anterior setae

F. A microbivorous, *Lepto-laimus* species (code 25) associated with the Cluster B sediment communities

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Appendix H

Field Notes and Transcripts
Relating to the Survey Works

Physalia

Table H1. Transcript of the field notes taken during the *KS Endeavor* residual impact survey benthic sampling, January 29th to February 2nd, 2016.

Survey: KSE		Date: 29/01/16	Staff: SJF, MWT, NR	Conditions: Calm, overcast			
Site	Depth (m)	Time	Sediment Description	Meio	Macro	PSD	Chem
1	14.0	9.37	Fine silt + underlying clay	***	*	*	*
5	11.0	11.03	Fine flocculant silt + clay	***	*	*	*
2	10.0	12.39	Silt/mud, stable	***	*	*	**
4	9.0	14.23	Fine silt over compact fine sand	***	X	*	*
7	10.6	16.52	Very fine silt, RDPL c. 4 cm	***	*	*	*
6	14.0	17.53	Very fine silt	***	*	*	*
3		19.09	Fine sand and silt	*	*	*	*
Survey: KSE		Date: 30/01/16	Staff: SJF, MWT, NR	Conditions: Calm/moderate swell			
Site	Depth (m)	Time	Sediment Description	Meio	Macro	PSD	Chem
8	15	7.57	Very fine sediment	***	*	*	*
9	13.6	9.02	Very fine silt	***	*	*	**
10	12	9.56	Very fine silt	***	*	*	*
31	13	10.33	Very fine silt	***	*	*	*
42	12	11.35	Fine silt topped with sand (c. 5 mm)	***	*	*	*
52	11.4	11.57	Fine silt with overlying sand (c. 5 mm)	***	*	*	*
63	11	12.37	Very fine silt (? iron staining)	***	*	*	*
73	12.7	14.23	Very fine silt	***	*	*	*
71	12.6	15.10	Very fine silt	***	*	*	*
68	12.7	16.00	Fine silt (c. 10 cm) with underlying clay	***	*	*	*
67	12.1	16.47	Fine silt	***	*	*	**
66	13.7	17.20	Fine silt	***	*	*	*

Physalia

Table H1, continued. Transcript of the field notes taken during the *KS Endeavor* residual impact survey benthic sampling, January 29th to February 2nd, 2016.

Survey: KSE		Date: 31/01/16	Staff: SJF, MWT, NR	Conditions: Overcast, calm/moderate swell			
Site	Depth (m)	Time	Sediment Description	Meio	Macro	PSD	Chem
48	13	7.53	Very very fine silt - sloppy	*	*	*	*
49	13.5	8.07	Very very fine silt - RDPL c. 10 cm	*	*	*	*
59	15	8.20	Very fine silt	*	*	*	*
60	12	8.37	Very fine silt - RDPL c. 2 cm	*	*	*	*
55	14	8.53	Very fine silt	*	*	*	*
43	13.8	9.27	Medium/fine sand over silt	*	*	*	*
38		10.03	Very very fine silt - sloppy	*	*	*	*
33	13.6	10.18	Very very fine silt - sloppy	*	*	*	*
34	13	10.40	Very fine silt	*	*	*	*
35	12	11.24	Very fine silt, plus some fine sand	*	*	*	*
36	12.2	11.44	Fine sand - 'clean', no silt	*	*	*	*
53	11	12.05	Very very fine silt (c. 7 cm) over medium/fine sand	*	*	*	*
62	12	12.24	Meduim sand (0.5 - 1 cm) over sandy silt	*	*	*	*
61	13	12.50	Very fine silt	*	*	*	*
56	18	14.37	Very fine sand - 'clean', no silt	*	*	*	*
44	10.3	15.35	Very fine sand - 'clean', no silt	*	0.75 l	*	*
39	11	15.57	Very fine sand - 'clean', occasional dark patches	*	0.5 l	*	*
40	10.5	16.35	Very fine sand - compact	*	0.25 l	*	*
45	10.6	16.58	Very fine sand - compact	*	*	*	*
57	26	17.15	Very fine sand - compact	*	*	*	*
58	12	17.36	2.5 cm fine sand over fine silt	*	*	*	*
46	12	17.52	Fine silt	*	*	*	*

Physalia

Table H1, continued. Transcript of the field notes taken during the *KS Endeavor* residual impact survey benthic sampling, January 29th to February 2nd, 2016

Physalia

Survey: KSE		Date: 01/02/16	Staff: SJF, MWT, NR	Conditions: Overcast, calm			
Site	Depth (m)	Time	Sediment Description	Meio	Macro	PSD	Chem
12	16.5	7.35	Silt with small proportion of shell debris	*	*	*	*
16	16	8.11	Silt with underlying clay	*	*	*	*
20	15.5	8.44	Very fine silt overlying silt with fine sand	*	*	*	*
23	17	9.30	Fine silt with some very fine sand below 5 cm	*	*	*	*
25	15	10.02	Fine silt overlying silt clay	*	*	*	*
22	13	10.38	Very very fine silt - sloppy	*	*	*	*
26	12	12.17	Very fine silt + clay	*	*	*	*
24	9.5	11.39	Very fine silt	*	*	*	*
21	11	12.17	Very fine silt	*	*	*	*
19	9.5	13.50	Very fine silt	*	*	*	*
15	8	14.16	Very fine silt	*	*	*	*
11	9	14.38	Very fine silt	*	*	*	*
14	10.5	15.40	Very fine silt	*	*	*	*
41	11.6	15.59	Silt with fine sand	*	*	*	*
64	12	16.14	Silt with 0.5 - 1 cm layer of overlying sand	*	*	*	*
69	11.7	16.37	Fine silt (c. 10 cm) overlying clay/silt	*	*	*	*
72	11.6	16.59	Very fine silt	*	*	*	*
74	12.1	17.19	Very fine silt	*	*	*	*
18	11.5	17.48	Fine silt with very fine sand	*	*	*	*
Survey: KSE		Date: 02/02/16	Staff: SJF, MWT, NR	Conditions: Overcast, calm			
Site	Depth (m)	Time	Sediment Description	Meio	Macro	PSD	Chem
30	13	9.17	Very fine silt	*	*	*	*
28	11	9.44	Very very fine silt - sloppy	*	*	*	*
47	43.8	10.22	Fine sand + patches of silt	*	*	*	*
51	45	10.57	Very fine silt (c. 10 cm) over muddy sand	*	*	*	*
54	44	12.11	Fine silt (c. 5 - 8 cm) over muddy sand	*	*	*	*
50	41	12.29	Very fine silt - sloppy	*	*	*	*
65	14.5	12.50	Very fine silt - sloppy	*	*	*	*
70	14	14.30	Very fine silt - sloppy	*	*	*	*
17	14	14.53	Sandy mud (fine sand)	*	*	*	*
13	14	15.16	Very fine silt, some clay	*	*	*	*
37	13.5	15.31	Very fine silt -possible oil residue (black)	*	*	*	*
32	13.5	16.02	Very fine silt	*	*	*	*
29	13.5	16.18	Very fine silt	*	*	*	*
27	13	16.36	Very fine silt	*	*	*	*

KS Endeavor Blowout Incident; Residual Marine Benthic Impact Assessment January - February 2016

Appendix I

Jones Environmental Laboratory Ltd Sediment Chemistry Analyses Report

Report Dated 23 March 2016

Physalia

Jones Environmental Laboratory

Registered Address : Unit 3 Deeside Point, Zone 3, Deeside Industrial Park, Deeside, CH5 2UA. UK

Unit 3 Deeside Point
Zone 3
Deeside Industrial Park
Deeside
CH5 2UA

Tel: +44 (0) 1244 833780
Fax: +44 (0) 1244 833781

Verde Environmental Consultants
Unit 27
Bullford Business Park
Kilcoole
Co Wicklow
Ireland

Attention :	Kevin Cleary
Date :	29th March, 2016
Your reference :	50686
Our reference :	Test Report 16/4574 Batch 1 Schedule F
Location :	KS Endeavor Impact
Date samples received :	5th February, 2016
Status :	Final report
Issue :	1

Seventy eight samples were received for analysis on 5th February, 2016 of which seventy six were scheduled for analysis. Please find attached our Test Report which should be read with notes at the end of the report and should include all sections if reproduced. Interpretations and opinions are outside the scope of any accreditation, and all results relate only to samples supplied.
All analysis is carried out on as received samples and reported on a dry weight basis unless stated otherwise. Results are not surrogate corrected.

Compiled By:

Paul Lee-Boden BSc
Project Manager

Jones Environmental Laboratory

Client Name: Verde Environmental Consultants
Reference: 50686
Location: KS Endeavor Impact
Contact: Kevin Cleary
JE Job No.: 16/4574

Report : Solid

Solids: V=60g VOC jar, J=250g glass jar, T=plastic tub

Please see attached notes for all abbreviations and acronyms

J E Sample No.	1-3	4-6	7-9	10-12	13-15	16-18	19-21	22-24	25-27	28-30			
Sample ID	KSE01	KSE02	KSE03	KSE04	KSE05	KSE06	KSE07	KSE08	KSE09	KSE10 (1)			
Depth													
COC No / misc													
Containers	V T	T V	V T	V T	V T	V T	V T	V T	V T	V T			
Sample Date	29/01/2016	29/01/2016	29/01/2016	29/01/2016	29/01/2016	29/01/2016	29/01/2016	30/01/2016	30/01/2016	30/01/2016			
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil			
Batch Number	1	1	1	1	1	1	1	1	1	1	LOD/LOR	Units	Method No.
Date of Receipt	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016			
Total Organic Carbon #	0.85	0.60	0.76	0.14	1.42	0.85	1.23	0.62	1.14	0.84	<0.02	%	TM21/PM24

Jones Environmental Laboratory

Client Name: Verde Environmental Consultants
Reference: 50686
Location: KS Endeavor Impact
Contact: Kevin Cleary
JE Job No.: 16/4574

Report : **Solid**

Solids: V=60g VOC jar, J=250g glass jar, T=plastic tub

Please see attached notes for all abbreviations and acronyms

J E Sample No.	31-33	34-36	37-39	40-42	43-45	46-48	49-51	52-54	55-57	58-60			
Sample ID	KSE10 (2)	KSE11	KSE12	KSE13	KSE14	KSE15	KSE16	KSE17	KSE18	KSE19			
Depth													
COC No / misc													
Containers	V T	V T	V T	V T	V T	V T	V T	V T	V T	V T			
Sample Date	30/01/2016	01/02/2016	01/02/2016	02/02/2016	01/02/2016	01/02/2016	01/02/2016	02/02/2016	01/02/2016	01/02/2016			
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil			
Batch Number	1	1	1	1	1	1	1	1	1	1	LOD/LOR	Units	Method No.
Date of Receipt	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016			
Total Organic Carbon #	0.80	1.36	0.48	0.66	1.21	0.90	0.24	0.33	1.15	1.45	<0.02	%	TM21/PM24

Jones Environmental Laboratory

Client Name: Verde Environmental Consultants
Reference: 50686
Location: KS Endeavor Impact
Contact: Kevin Cleary
JE Job No.: 16/4574

Report : Solid

Solids: V=60g VOC jar, J=250g glass jar, T=plastic tub

Please see attached notes for all abbreviations and acronyms

J E Sample No.	61-63	64-66	67-69	70-72	73-75	76-78	79-81	82-84	85-87	88-90			
Sample ID	KSE20	KSE21	KSE22	KSE23	KSE24	KSE25	KSE26	KSE27	KSE28	KSE29			
Depth													
COC No / misc													
Containers	V T	V T	V T	V T	V T	V T	V T	V T	V T	V T			
Sample Date	01/02/2016	01/02/2016	01/02/2016	01/02/2016	01/02/2016	01/02/2016	01/02/2016	02/02/2016	02/02/2016	02/02/2016			
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil			
Batch Number	1	1	1	1	1	1	1	1	1	1	LOD/LOR	Units	Method No.
Date of Receipt	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016			
Total Organic Carbon #	0.47	1.36	1.67	0.23	1.81	0.50	0.89	1.28	0.74	1.09	<0.02	%	TM21/PM24

Please include all sections of this report if it is reproduced
All solid results are expressed on a dry weight basis unless stated otherwise.

Jones Environmental Laboratory

Client Name: Verde Environmental Consultants
Reference: 50686
Location: KS Endeavor Impact
Contact: Kevin Cleary
JE Job No.: 16/4574

Report : Solid

Solids: V=60g VOC jar, J=250g glass jar, T=plastic tub

Please see attached notes for all abbreviations and acronyms

J E Sample No.	91-93	94-96	97-99	100-102	103-105	106-108	109-111	112-114	115-117	118-120			
Sample ID	KSE30	KSE31	KSE32	KSE33	KSE34	KSE35	KSE36	KSE37	KSE38	KSE39			
Depth													
COC No / misc													
Containers	V T	V T	V T	V T	V T	V T	V T	V T	V T	V T			
Sample Date	02/02/2016	30/01/2016	02/02/2016	31/01/2016	31/01/2016	31/01/2016	31/01/2016	02/02/2016	31/01/2016	31/01/2016			
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil			
Batch Number	1	1	1	1	1	1	1	1	1	1	LOD/LOR	Units	Method No.
Date of Receipt	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016			
Total Organic Carbon #	1.13	1.10	1.11	1.40	1.05	1.31	0.14	1.05	1.19	<0.02	<0.02	%	TM21/PM24

Please include all sections of this report if it is reproduced
All solid results are expressed on a dry weight basis unless stated otherwise.

Jones Environmental Laboratory

Client Name:	Verde Environmental Consultants	**Report :**	**Solid**
Reference:	50686		
Location:	KS Endeavor Impact	**Solids:**	V=60g VOC jar, J=250g glass jar, T=plastic tub
Contact:	Kevin Cleary		
JE Job No.:	16/4574		

Please see attached notes for all abbreviations and acronyms

J E Sample No.	121-123	124-126	127-129	130-132	133-135	136-138	139-141	142-144	145-147	148-150			
Sample ID	KSE40	KSE41	KSE42	KSE43	KSE44	KSE45	KSE46	KSE47	KSE48	KSE49			
Depth													
COC No / misc													
Containers	V T	V T	V T	V T	V T	V T	V T	V T	V T	V T			
Sample Date	31/01/2016	01/02/2016	30/01/2016	31/01/2016	31/01/2016	31/01/2016	31/01/2016	02/02/2016	31/01/2016	31/01/2016			
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil			
Batch Number	1	1	1	1	1	1	1	1	1	1	LOD/LOR	Units	Method No.
Date of Receipt	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016			
Total Organic Carbon #	0.03	0.72	0.60	1.06	<0.02	<0.02	1.33	0.14	1.28	1.13	<0.02	%	TM21/PM24

Please include all sections of this report if it is reproduced
All solid results are expressed on a dry weight basis unless stated otherwise.

Jones Environmental Laboratory

Client Name: Verde Environmental Consultants
Reference: 50686
Location: KS Endeavor Impact
Contact: Kevin Cleary
JE Job No.: 16/4574

Report : Solid

Solids: V=60g VOC jar, J=250g glass jar, T=plastic tub

Please see attached notes for all abbreviations and acronyms

J E Sample No.	151-153	154-156	157-159	160-162	163-165	166-168	169-171	172-174	175-177	178-180			
Sample ID	KSE50	KSE51	KSE52	KSE53	KSE54	KSE55	KSE56	KSE57	KSE58	KSE59			
Depth													
COC No / misc													
Containers	V T	V T	V T	V T	V T	V T	V T	V T	V T	V T			
Sample Date	02/02/2016	02/02/2016	30/01/2016	31/01/2016	02/02/2016	31/01/2016	31/01/2016	31/01/2016	31/01/2016	31/01/2016			
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil			
Batch Number	1	1	1	1	1	1	1	1	1	1	LOD/LOR	Units	Method No.
Date of Receipt	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016			
Total Organic Carbon #	1.28	0.57	0.68	1.05	1.20	1.29	0.02	<0.02	0.26	0.74	<0.02	%	TM21/PM24

Please include all sections of this report if it is reproduced
All solid results are expressed on a dry weight basis unless stated otherwise.

Jones Environmental Laboratory

Client Name: Verde Environmental Consultants
Reference: 50686
Location: KS Endeavor Impact
Contact: Kevin Cleary
JE Job No.: 16/4574

Report : Solid

Solids: V=60g VOC jar, J=250g glass jar, T=plastic tub

Please see attached notes for all abbreviations and acronyms

J E Sample No.	181-183	184-186	187-189	190-192	193-195	196-198	199-201	202-204	205-207	208-210			
Sample ID	KSE60	KSE61	KSE62	KSE63	KSE64	KSE65	KSE66	KSE67 (1)	KSE67 (2)	KSE68			
Depth													
COC No / misc													
Containers	V T	V T	V T	V T	V T	V T	V T	V T	V T	V T			
Sample Date	31/01/2016	31/01/2016	31/01/2016	30/01/2016	01/02/2016	02/02/2016	30/01/2016	30/01/2016	30/01/2016	30/01/2016			
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil			
Batch Number	1	1	1	1	1	1	1	1	1	1	LOD/LOR	Units	Method No.
Date of Receipt	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016			
Total Organic Carbon #	0.71	1.27	5.49	1.30	1.13	1.14	1.10	1.38	1.21	1.38	<0.02	%	TM21/PM24

Jones Environmental Laboratory

Client Name: Verde Environmental Consultants
Reference: 50686
Location: KS Endeavor Impact
Contact: Kevin Cleary
JE Job No.: 16/4574

Report : Solid

Solids: V=60g VOC jar, J=250g glass jar, T=plastic tub

Please see attached notes for all abbreviations and acronyms

J E Sample No.	211-213	214-216	217-219	220-222	223-225	226-228							
Sample ID	KSE69	KSE70	KSE71	KSE72	KSE73	KSE74							
Depth													
COC No / misc													
Containers	V T	V T	V T	V T	V T	V T							
Sample Date	01/02/2016	02/02/2016	30/01/2016	01/02/2016	30/01/2016	01/02/2016							
Sample Type	Soil	Soil	Soil	Soil	Soil	Soil							
Batch Number	1	1	1	1	1	1					LOD/LOR	Units	Method No.
Date of Receipt	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016	05/02/2016							
Total Organic Carbon #	0.81	1.02	1.04	1.03	1.14	1.27					<0.02	%	TM21/PM24

NOTES TO ACCOMPANY ALL SCHEDULES AND REPORTS

JE Job No.: 16/4574

SOILS

Please note we are only MCERTS accredited (UK soils only) for sand, loam and clay and any other matrix is outside our scope of accreditation.

Where an MCERTS report has been requested, you will be notified within 48 hours of any samples that have been identified as being outside our MCERTS scope. As validation has been performed on clay, sand and loam, only samples that are predominantly these matrices, or combinations of them will be within our MCERTS scope. If samples are not one of a combination of the above matrices they will not be marked as MCERTS accredited.

It is assumed that you have taken representative samples on site and require analysis on a representative subsample. Stones will generally be included unless we are requested to remove them.

All samples will be discarded one month after the date of reporting, unless we are instructed to the contrary.

If you have not already done so, please send us a purchase order if this is required by your company.

Where appropriate please make sure that our detection limits are suitable for your needs, if they are not, please notify us immediately.

All analysis is reported on a dry weight basis unless stated otherwise. Results are not surrogate corrected. Samples are dried at 35°C ±5°C unless otherwise stated. Moisture content for CEN Leachate tests are dried at 105°C ±5°C.

Where Mineral Oil or Fats, Oils and Grease is quoted, this refers to Total Aliphatics C10-C40.

Where a CEN 10:1 ZERO Headspace VOC test has been carried out, a 10:1 ratio of water to wet (as received) soil has been used.

% Asbestos in Asbestos Containing Materials (ACMs) is determined by reference to HSG 264 The Survey Guide - Appendix 2 : ACMs in buildings listed in order of ease of fibre release.

Negative Neutralization Potential (NP) values are obtained when the volume of NaOH (0.1N) titrated (pH 8.3) is greater than the volume of HCl (1N) to reduce the pH of the sample to 2.0 - 2.5. Any negative NP values are corrected to 0.

WATERS

Please note we are not a UK Drinking Water Inspectorate (DWI) Approved Laboratory .

ISO17025 (UKAS) accreditation applies to surface water and groundwater and one other matrix which is analysis specific, any other liquids are outside our scope of accreditation.

As surface waters require different sample preparation to groundwaters the laboratory must be informed of the water type when submitting samples.

Where Mineral Oil or Fats, Oils and Grease is quoted, this refers to Total Aliphatics C10-C40.

DEVIATING SAMPLES

Samples must be received in a condition appropriate to the requested analyses. All samples should be submitted to the laboratory in suitable containers with sufficient ice packs to sustain an appropriate temperature for the requested analysis. If this is not the case you will be informed and any test results that may be compromised highlighted on your deviating samples report.

SURROGATES

Surrogate compounds are added during the preparation process to monitor recovery of analytes. However low recovery in soils is often due to peat, clay or other organic rich matrices. For waters this can be due to oxidants, surfactants, organic rich sediments or remediation fluids. Acceptable limits for most organic methods are 70 - 130% and for VOCs are 50 - 150%. When surrogate recoveries are outside the performance criteria but the associated AQC passes this is assumed to be due to matrix effect. Results are not surrogate corrected.

DILUTIONS

A dilution suffix indicates a dilution has been performed and the reported result takes this into account. No further calculation is required.

NOTE

Data is only reported if the laboratory is confident that the data is a true reflection of the samples analysed. Data is only reported as accredited when all the requirements of our Quality System have been met. In certain circumstances where all the requirements of the Quality System have not been met, for instance if the associated AQC has failed, the reason is fully investigated and documented. The sample data is then evaluated alongside the other quality control checks performed during analysis to determine its suitability. Following this evaluation, provided the sample results have not been effected, the data is reported but accreditation is removed. It is a UKAS requirement for data not reported as accredited to be considered indicative only, but this does not mean the data is not valid.
Where possible, and if requested, samples will be re-extracted and a revised report issued with accredited results. Please do not hesitate to contact the laboratory if further details are required of the circumstances which have led to the removal of accreditation.

JE Job No.: 16/4574

ABBREVIATIONS and ACRONYMS USED

#	ISO17025 (UKAS) accredited - UK.
B	Indicates analyte found in associated method blank.
DR	Dilution required.
M	MCERTS accredited.
NA	Not applicable
NAD	No Asbestos Detected.
ND	None Detected (usually refers to VOC and/SVOC TICs).
NDP	No Determination Possible
SS	Calibrated against a single substance
SV	Surrogate recovery outside performance criteria. This may be due to a matrix effect.
W	Results expressed on as received basis.
+	AQC failure, accreditation has been removed from this result, if appropriate, see 'Note' on previous page.
++	Result outside calibration range, results should be considered as indicative only and are not accredited.
*	Analysis subcontracted to a Jones Environmental approved laboratory.
AD	Samples are dried at 35°C ±5°C
CO	Suspected carry over
LOD/LOR	Limit of Detection (Limit of Reporting) in line with ISO 17025 and MCERTS
ME	Matrix Effect
NFD	No Fibres Detected
BS	AQC Sample
LB	Blank Sample
N	Client Sample
TB	Trip Blank Sample
OC	Outside Calibration Range

Jones Environmental Laboratory

Method Code Appendix

JE Job No: 16/4574

Test Method No.	Description	Prep Method No. (if appropriate)	Description	ISO 17025 (UKAS)	MCERTS (UK soils only)	Analysis done on As Received (AR) or Dried (AD)	Reported on dry weight basis
TM21	Modified USEPA 415.1. Determination of Total Organic Carbon or Total Carbon by combustion in an Eltra TOC furnace/analyser in the presence of oxygen. The CO2 generated is quantified using infra-red detection.	PM24	Dried and ground solid samples are washed with hydrochloric acid, then rinsed with deionised water to remove the mineral carbon before TOC analysis.	Yes		AD	Yes

Assessment & ranking of ecologically significant contaminants (ARESC) - Bio-sentinel system monitoring - Biodiversity database development - Cohort analyses - Community geometric mean studies - Contaminated land assessment & monitoring - Ecological risk assessment - Ecotoxicological studies - Effluent component monitoring - Ecological impact predictions for proposed developments - Ecological mitigation studies - Ecological/physico-chemical trend analyses - Fouling & biocide monitoring - Forensic studies - Growth performance stress assessment - Impact assessment & analyses - Incident monitoring & analyses - Indicator species analyses (ISA) - Local indicator of spatial association (LISA) Analyses - Mantel matrix analysis studies - Meiofaunal analyses for the establishment of prevailing environmental conditions - Meiofaunal colonisation unit (MCU) surveys - Monte Carlo permutation test studies - Multivariate data analyses for biological & non-biological data sets - Multivariate Groundwater Tracking Analyses (MVGTA) - Parasitological Assessments - Parallax corrected spatial determinations - Performance & monitoring index derivation - Photomicroscopy & Photomacrography - Remediation measure performance testing & monitoring - Sediment contaminant assessment plot (SCAP) analyses - Scientific & technical photography - Spatial autocorrelation analyses - Spatial & temporal trend analyses - Spectral analyses of algal/floral assemblages for stress detection & community assessments - Stress & contaminant hotspot analyses - Terrestrial meiofauna analyses (TMA) - Taxonomic distinctness & taxonomic diversity indices analyses - Taxonomic studies -

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